VOYA

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# Distribution and Abundance of River Otter in Voyageurs National Park, Minnesota

United States Department of the Interior

National Park Service
Midwest Region

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# DISTRIBUTION AND ABUNDANCE OF RIVER OTTER

# IN VOYAGEURS NATIONAL PARK, MINNESOTA

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NATIONAL PARK SERVICE - Midwest Region

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# DISTRIBUTION AND ABUNDANCE OF RIVER OTTER IN VOYAGEURS NATIONAL PARK, MINNESOTA

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Astract: River otter (*Lutra canadensis*) distribution and abundance in relation to man-caused water fluctuations was studied from April 1985 to March 1987 in Voyageurs National Park (VNP), Minnesota. Baseline data were collected on the otter population and comparisons made between study areas with less-than-natural (Rainy Lake) and greater-than-natural (Namakan Reservoir) water fluctuations.

Thirty-nine otter were live-trapped with a combined success rate of 41.1 trap-nights/otter (spring $\bar{X} = 13.9$; fall $\bar{X} = 72.6$). Nineteen of these were radiomonitored for a total of 1,098 locations. From direct observations a minimum of 270 otters (1 otter/3.6 km of shoreline) inhabited the large lakes in VNP during summer 1986. Mean productivity was estimated at 2.6 young per breeding female. Two live-trapped otters were known to have had naturally occuring urinary infections and one suffered from adrenal failure. One natural death was documented when a female otter was killed by wolves.

Home range area varied from 0.64 $km^2$ for a yearling female in winter to 29.13 $km^2$ for an adult male in summer. Adult males had larger summer home range areas ($\bar{X} = 21.38$ $km^2$) and more total shoreline available ($\bar{X} = 50.41$ km) than did adult females (area $\bar{X} = 3.46$ $km^2$; shoreline $\bar{X} = 12.78$ km) but during winter there was no difference between sexes (male area $\bar{X} = 7.58$ $km^2$; male shoreline $\bar{X} = 21.71$ km ; female area $\bar{X} = 5.75$ $km^2$; female shoreline $\bar{X} = 15.21$ km). Area and total shoreline available within summer home ranges of adult males were significantly larger than their respective winter home ranges but the same was not true for adult females.

Otters moved freely between large lakes and adjacent inland lakes and ponds in summer. While most radioed otters stayed on the large lakes in winter, 16-35% moved to inland waters and made little or no use of the large lakes.

Fish and crayfish were the most important prey of otters, occurring in 72% and 71% respectively of 796 scats analyzed; however, the relative importance of the two prey varied with season and water regime. Use of fish remained high on Rainy Lake during both summer and winter but crayfish became more important in the summer diet of otters in Namakan Reservoir.

A method based on fresh sign and known movements of radioed otters was developed for comparing relative abundance. Using this method, no difference was detected in otter abundance between Rainy Lake and Namakan Reservoir. Home range size was not significantly different between adult female otters using the two study areas and insufficient data existed to test between males; however, the large winter drawdown on Namakan Reservoir likely contributed to seasonal shifts in female home ranges. It is postulated that water fluctuations contribute to the detritus load of Namakan Reservoir Lakes, thereby causing a rapid increase in crayfish abundance and accounting for the observed differences in otter feeding habits between the two water regimes.

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# INTRODUCTION

Voyageurs National Park (VNP) was established in 1975 because of its historic significance in the fur trade, its scenic beauty, and its scientific value as the only national park in a mainland southern boreal forest (Cole 1982). Approximately 39% of the 891 $km^2$ (344 $mi^2$) park is covered with water (Kallemeyn 1985). Small creeks, rivers, ponds, small interior lakes, and four large lakes with numerous bays and backwater sloughs provide excellent habitat for semi-aquatic mammals such as the river otter (Lutra canadensis).

Man-made dams outside VNP regulate water levels of the four large lakes, Rainy, Kabetogama, Namakan, and Sand Point that are partly or entirely within VNP boundaries (Fig. 1). The Rainy Lake dam, situated on Rainy River between International Falls, Minnesota and Fort Francis, Ontario, was completed in 1909 while twin dams at the outlet of Namakan Reservoir (including Namakan, Kabetogama and Sand Point Lakes) were completed in 1914. Their operation and subsequent lake levels are controlled by the Canada and United States International Joint Commission (IJC), which considers water for navigation, flood control, pollution abatement, hydroelectric power, fish spawning, and wild rice propagation (Flug 1986).

Currently the IJC authorizes a seasonal water fluctuation of approximately 1.0 meter on Rainy Lake to provide water for power generation at International Falls and Fort Francis. This "less-than-natural" fluctuation is accomplished by maintaining a "greater-than-natural" fluctuation of 2.7 meters on the Namakan Reservoir (Fig. 2). Undamned, Namakan Reservoir would fluctuate approximately 1.9 meters annually (Flug 1986). Perhaps of greater biological significance, regulated water levels differ from natural fluctuations by: 1) reaching peak levels in late June or early July rather than late May or early June; 2) remaining relatively stable over summer and fall rather than gradually declining; and 3) declining 2.3 meters over winter rather than 0.3 meters, a 7-fold difference (Flug 1986).

The National Park Service has conducted or contracted several studies to investigate the possible impacts of these artificial water fluctuations on VNP's natural resources. These include: water productivity, benthic invertebrates, aquatic plants, several species of fish, shore and marsh nesting birds, osprey (Pandion haliaetus), and several species of semi-aquatic mammals, including river otter.

The objectives of the river otter study, as outlined by the National Park Service's Scope of Work, were to:

1) Review historical records on distributions, abundance, and known removals of otter from VNP;

2) Conduct a systematic survey of present distributions and abundance of otter in and adjacent to VNP;

3) Use survey results to compare study areas with less-than-natural (Rainy Lake) and greater-than-natural (Namakan Reservoir) water level fluctuations;

4) Test for differences in abundance, food habits and mortality and/or dispersal rates between areas; and

5) Compare results from this study to probable natural conditions, and otter abundance elsewhere, and use these comparisons to predict future trends in otter distributions with or without changes in the way lake levels are regulated.

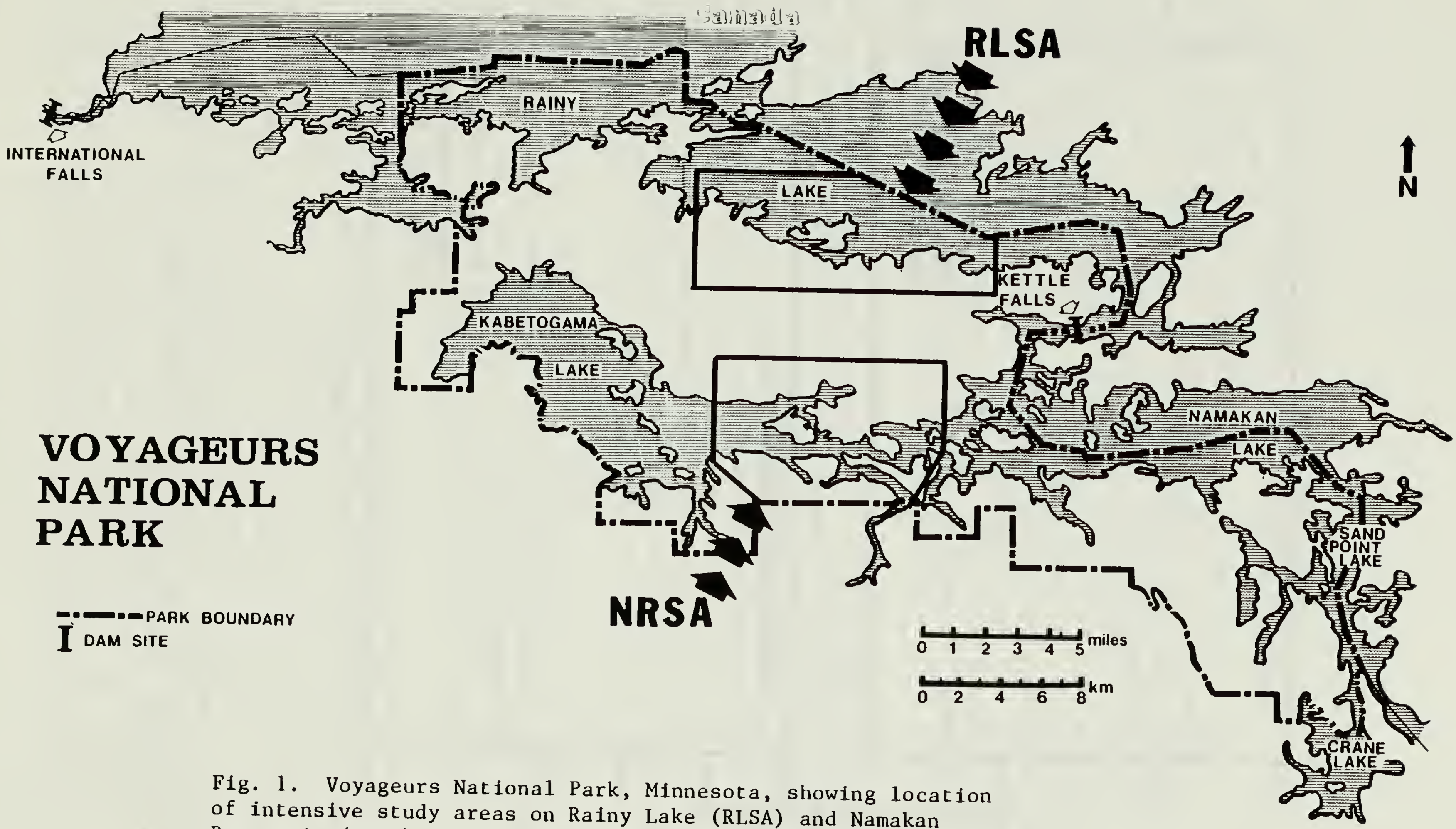


Fig. 1. Voyageurs National Park, Minnesota, showing location of intensive study areas on Rainy Lake (RLSA) and Namakan Reservoir (NRSA). Note: Namakan Reservoir consists of Kabetogama, Namakan, and Sand Point Lakes.

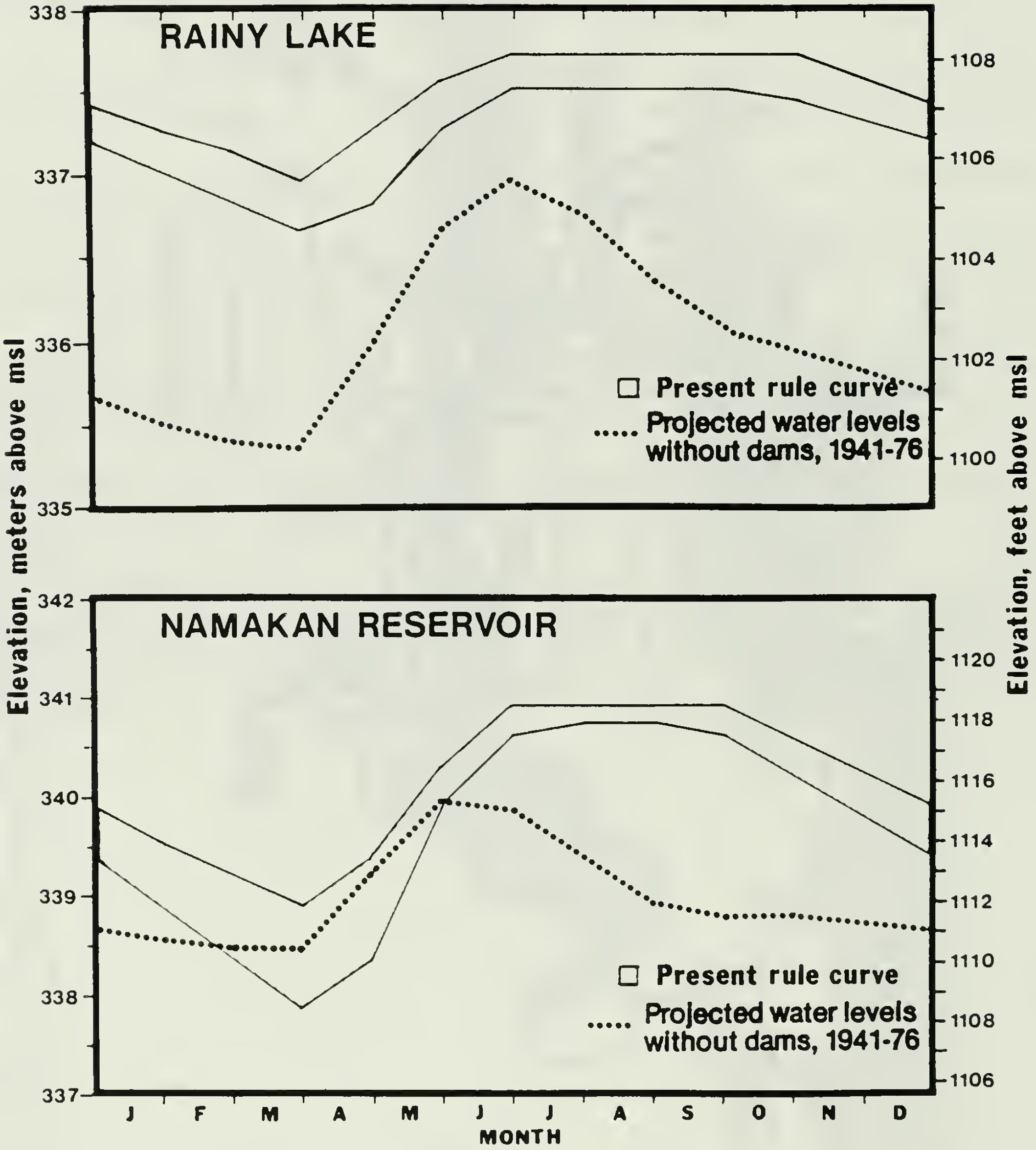


Fig. 2. Present rule curve and projected natural water levels for Rainy Lake and Namakan Reservoir, VNP, Minnesota. From Flug 1986.

# HISTORICAL PERSPECTIVE ON OTTER IN THE REGION

Little historical information exists on river otter abundance, but accounts of the fur trade indicate that otters were prized and heavily harvested in North America starting in the late 1600s (Swanson 1940; Schorger 1970; Jenkins 1983). In fact, on the basis of 100 for otter, beaver (Castor canadensis) were rated as 90% and muskrat (Ondatra zibethicus as 45% in wearing quality (Innis 1927). Beaver, however, were more easily trapped and provided the bulk of the early fur trade. Consequently, by the first half of the 19th century, beaver numbers were drastically reduced in the Lake States Region and otters became at least as plentiful as the beaver (Schorger 1970).

That otters were heavily trapped in the Lake States Region in the early 1800s is apparent from records kept by the American Fur Company. At the company's northern outpost on Madeline Island, Wisconsin, where furs were primarily taken from northern Wisconsin, 4,831 otter pelts were traded in 1835 alone (Appendix 1). By comparison, Wisconsin's harvest between 1973 and 1982 averaged only 1,109 otters annually (Kohn and Ashbrenner 1984) and the Minnesota Department of Natural Resources (MDNR) estimated Minnesota's total spring otter population for 1988 at around 6,000 (Boggess and Berg 1987).

The American Fur Company's records (Appendix 1) show a steady decline in the number of otter furs being traded even though fur prices remained high. Although harvest may not reflect abundance, the records suggest otters were being depleted in the Lake States Region in the late 1800s.

MDNR has unpublished trapping records dating back to 1867 (Appendix 2), but detailed records of otter harvests were rarely kept until 1955. The records show otter trapping was closed from 1917-1944 and again from 1946-1950 because of low population levels. The data are useful for examining when and to what extent otter were being harvested; however, methods for estimating harvest varied so that direct comparisons between years were not feasible (Landwehr 1982).

Ultimately, unregulated trapping and hunting, habitat destruction, and water pollution, severely restricted the otter's distribution (Nilsson and Vaughn 1978). By 1935, otter were extirpated from two-thirds of their previous range in North America (Jenkins 1983), including southern

Minnesota (Gunderson and Beer 1953). However, remote regions served as refugia where otter numbers remained at relatively low levels. Quetico Provincial Park, formed in 1913, provided the first protection for furbearing mammals in the region (Walshe 1984). By 1916, Quetico Superintendent A.J. McDonald boasted that otters were again "numerous" and on October 12, 1916 opened a season for both otter and beaver. Again, in 1934, otter in Quetico were said to be "multiplying fast" (Walshe 1984).

In 1977 the Fund For Animals (a conservation organization) petitioned to place river otter on the Endangered Species List. This resulted in their being included on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1977 (Greenwalt 1977). Inclusion of the otter on the CITES list prompted several studies on various aspects of otter ecology. In 1978 MDNR began using harvest data to simulate Minnesota's otter population (Appendix 3). At present, northern Minnesota is fortunate to have a relatively large otter population that appears to be increasing by 1%-3% annually (B. Berg, MDNR. pers. comm.).

## STUDY AREA

Situated in extreme northern Minnesota, Voyageurs National Park (VNP) is bordered on the northeast by roadless portions of Ontario and on the south by portions of Superior National Forest and Kabetogama State Forest. To the west and south lie more inhabited areas, including Fort Francis, Ontario; International Falls, Minnesota; and the smaller resort communities of Kabetogama and Crane Lake, Minnesota (Fig. 1).

The four large lakes in VNP vary greatly in size, depth, and volume (Appendix 4). Kabetogama Lake is distinct in being shallow, more biologically productive, and having more than twice the overall summer density of zooplankton than the other three lakes (Kepner and Stottlemyer 1988). In addition to the large lakes, there are 26 smaller lakes, ranging from 13 to 305 hectares in size (VNP unpubl. data), and over 400 small beaver impoundments (D. Smith, Mich. Tech. Univ., unpubl. data).

The climate is midcontinental with long cold winters of moderately heavy snowfall and summers that are warm and moist. Temperatures average 18.6°C in July and -16.1°C in

January but extremes vary from -43°C to 36.6°C (Cole 1987). There are 95 frost-free days and a mean annual precipitation of 627mm (Kurmis et al. 1986). Freeze-up of VNP lakes usually occurs around the third week in November with spring break-up occuring about May 1 (Kallemeyn 1987).

Vegetation in VNP is typical of southern boreal forest, with glaciation being the major force affecting vegetation origins (Kurmis et al. 1986). VNP forests were extensively logged in the early 1900s but since VNP's establishment in 1975, logging has been prohibited and natural fires have been suppressed. Although small-scale disturbance by wind storms, disease and herbivory do occur, the forest is tending towards climax communities dominated by white spruce-balsam fir (*Picea glauca*-*Abies balsamea*) on mineral soils, and black spruce (*P. mariana*) on peat soils (Cole 1982).

### Intensive Study Areas

Home range and distribution and abundance studies were confined to two intensive study areas in VNP. The Rainy Lake Study Area (RLSA) comprised 88.86 km of shoreline on the main lake, including islands, while the Namakan Reservoir Study Area (NRSA) contained 81.78 km of shoreline on the reservoir, including islands (Fig. 1).

## METHODS AND MATERIALS

### Capture and Biotelemetry

River otters were captured using Hancock live-traps (Hancock Trap Co., Hot Springs, SD) set in overland trails and at pullout sites. All traps were camouflaged with natural material found at the site. To prevent otter escape we modified the traps as did Northcott and Slade (1976) and Melquist and Hornocker (1979a).

All captured otters were anesthetized with an intramuscular injection of ketamine hydrochloride (initial dose of 1.5cc with additional doses of 0.5cc, if necessary). Standard body measurements were taken, and each otter was marked with a monel ear tag (National Band and Tag Co., Newport, KY). Hair clippings were taken from each otter and sent to the Minnesota Pollution Control Agency (MPCA) for analysis of mercury concentrations. Otters were then inspected for tooth wear and overall condition before either being released (at least two hours after anesthesia) or transported to a surgical facility. Overall condition was indexed by assessing the animal's responsiveness before drugging with the prominence of vertebral processes (C. Logsdon, in Kuehn 1984). Prior to release, otters were placed at the capture site and allowed to recover from anesthesia in a wooden holding cage or closed Hancock trap with water available. Hancock traps were covered with foliage to reduce stress from external stimuli.

Captured otters were classified as juveniles (< 1 yr), yearlings (1-2 yrs) or adults (> 2 yrs). We initially separated otters into three groups using a clustering procedure with weight and zygomatic breadth as variables. Tooth wear, date of capture, evidence of lactation and knowledge of individual otter life histories (if available) were other criteria used to subjectively age-class otters. Additionally, age was determined by MDNR for 16 otter carcasses obtained from trappers adjacent to VNP using annular cementum layers (Kuehn and Berg 1983) (Appendix 5). These "known aged" otter were useful for assessing our age-class criteria.

Radio transmitters (95 x 33mm; 85-90 grams) (Model 400L, Telonics Inc., Mesa, Az) were surgically implanted into the peritoneal cavity of live-captured otters. Otters are susceptible to gastroenteritis caused by stress from handling and transport (Jalkotzy 1982; Melquist and Hornocker 1983; Kuehn 1984; Reid 1984). This stress was reduced by conducting surgeries at a centrally located facility within a 15-minute boat ride from capture sites. All but one surgery was preformed by the author; on one occasion a visiting veterinarian (J. Fisher) performed the surgery. Surgical techniques were similar to those reported by Melquist and Hornocker (1979b) and Reid (1984) and will be reported in more detail elsewhere (Route and Smith, in preparation).

Chi-square analyses (Zar 1974) were performed to test for differences in trap success between sexes, seasons and lakes at the 0.05 significance level.

## Home Range and Movement Patterns

Methods and intensity of locating radioed otters varied with season. Transmitted otters were located primarily by boat during summer (ice-free) periods. A 2-element beam antenna atop a 2-meter PVC pipe and connected to a TR-2 receiver (Telonics, Inc. Mesa, Az) with a head-set was used to scan for otters along lakeshores. This method usually brought the observer to within 20 meters of the otter since most otters remained close to shore. When the animal was inland, an attempt was made to hike overland for an accurate location. If an exact location was not possible, it was estimated by triangulation.

When no signal was received, the known home range was searched by boat and inland areas were checked on foot. If the animal was still not located, no further attempt was made that day. During ice-free periods we occasionally made aerial locations from a VNP-operated Piper Supercub with strut-mounted antenna.

In winter (ice-up) periods, otters were radio-located twice each week from aircraft. During the winter of 1985-86 telemetry flights were made at various times throughout the week depending on weather and on pilot, aircraft and observer availability. During the winter of 1986-87, flight times also varied but were scheduled two days in succession and timed to coincide with track surveys (see Distribution and Abundance section). Throughout both winters, attempts were made to locate each otter from snowmobile or on foot using hand-held antenna at least once each week.

All locations were given X and Y map coordinates using the Universal Transverse Mercator (UTM) system on 1:24,000-scale topographic maps. Date, time, type of location (whether aerial, triangulated, or close approach on the ground), nearest body of water, and any observations were noted for each location.

The distance between consecutive-day locations (20 to 28 hour intervals) was calculated as the straight-line distance between the two locations. The resulting distances were used to test for differences in movement patterns between otters in the two intensive study areas using an analysis of variance (ANOVA) procedure at the 0.05 significance level.

Recent probabilistic models for estimating home range assume temporal and spacial homogeneity in sampling intensity (Van Winkle 1975; Dixon and Chapman 1980), an assumption often violated in studies of far-ranging animals such as otters (Garshelis 1983). Therefore, we defined home range as the area within a minimum convex polygon formed by connecting the outer-most points of location (Mohr 1947). Home range area and length of shoreline were measured using a Geographical Information System (GIS) Module and Earth Resources Data Analysis System (ERDAS) software on 1:24,000-scale maps.

## Track Surveys

Otters are difficult to observe and do not inhabit lodges or dens that can be easily identified and enumerated. Several techniques have been employed to index otter abundance in various parts of their range (Erlinge 1967; Knaus et al. 1984; Mason and Macdonald 1987), but no method has been rigorously tested or accepted (Kruuk and Conroy 1987).

The occurrence of above-ice otter sign was used to compare regulated lakes during the first winter of study (1985-86). Four track surveys were conducted by snowmobile along lakeshores on both Rainy Lake and Namakan Reservoir (first winter surveys were not restricted to intensive study areas). All otter sign was recorded using UTM coordinates, but age of sign was not determined. Straight-line distances between sign were used to test (ANOVA at 0.05) the hypothesis of no difference between Rainy Lake and Namakan Reservoir.

Surveys were intensified during winter 1986-87 by making repeated searches for all otter sign on RLSA and NRSA on the same day. This survey design was replicated six times for both study areas and on one additional occasion for NRSA. Observers attempted to identify all otter sign, estimate whether the sign was fresh (<24 hours old) or old (>24 hours old), and when possible, estimate the number of otters present. Sign per km of shoreline surveyed and mean straight-line distance to the next fresh sign were used to make comparisons between the two water regimes. An ANOVA was used to test the hypothesis of no difference in the distance between fresh sign. Because of unequal sample variances, the Friedman test (a non-parametric two-way ANOVA by ranks) (Conover 1971) was used to test the hypothesis of no difference in the number of otter sign per km of shoreline.

## Present Abundance

We used two methods to estimate otter abundance in each of the intensive study areas. Method 1 was used to project our final estimate of abundance within VNP while method 2 was used only to compare relative abundance between study areas.

Method 1: During the 1986 ice-free field season, the number of otters in each intensive study area was estimated by directly observing radio-marked and unmarked otters. During and immediately following the spring mating season adult male otters tended to be active and observable throughout the day. Adult females and young were more easily observed in early morning and late afternoon during fall. Sitings throughout the ice-free field season were then compared to make a final estimate of the population.

Method 2: A second, less subjective, estimate of the population was based on above-ice tracks and other sign observed during the winter of 1986-87. Fresh otter sign observed during replicate surveys were plotted on maps of home ranges estimated for radioed otters (see Home Range and Movements section). Our estimates for each survey were then calculated using the following 8 steps:

Step 1: All fresh otter sign observed was plotted on a 1:24,000-scale map of the study area.

Step 2: Estimated winter home ranges of radioed otters on RLSA and NRSA during the winter of 1986-87 were superimposed on maps of fresh otter sign from step 1.

Step 3: Fresh sign occurring within a radioed otter's home range was assumed to have been made by that otter and its associated family members. These otters were then counted, but only if they were located on the shoreline of the intensive study area during that survey.

Step 4: Fresh otter sign occurring outside of radioed otter home ranges were assumed to have been made by unmarked otter groups (1 or more otters). Each of these were considered as separate and unique (i.e., made by different unmarked groups) only if separated by more than 3 km (3 km rule based on data from Home Range and Movements section).

Step 5: The average number of otters per group was calculated from winter 1985-86 and winter 1986-87 survey data. To limit observer bias, we used data from widely separated observations of only two observers. This average was then applied to the number of additional groups as designated from step 4.

Step 6: The probability of a group being detected by above-ice sign was calculated as:

$P=D/T$

where:

P= The probability of a group being detected by sign.
D= The number of radioed otter groups that were detected by fresh sign occurring within their home range during the survey.
T= The total number of radioed otter groups on the shoreline of the intensive study area during the survey.

Step 7: Total km of shoreline searched for otter sign during each survey was measured using a GIS Module and ERDAS software on 1:24,000-scale maps.

Step 8: Our final estimate for each survey was calculated as:

$N= (R+(A/P))/KM$

where:

N= the estimated number of otters/km of shore surveyed.
R= the known number of radioed otters and associated family members known to be in the intensive study area during the survey.
A= the number of additional otters using the shoreline of the lake as determined from fresh sign occurring outside of known home ranges.
P= the probability of being detected by tracks during the survey.
KM= total kilometers of shoreline surveyed.

A final estimate of the number of otters inhabiting the study areas was made by taking an average of all 1986-87 winter surveys. Differences between study areas were tested using t-tests at a 0.05 significance level.

### Food Habits

Otter scats were collected from five areas: 1) Rainy Lake; 2) Kabetogama Lake; 3) Namakan Lake; 4) Sand Point Lake; and 5) inland waters, including the "Chain of Lakes" (Locator, War Club, Quill and Loiten Lakes) and several beaver drainages.

During summer, monthly collections were made of all scats found at designated otter latrine sites on the four large lakes and the Chain of Lakes. Summer scats from other small lakes and beaver drainages were collected incidentally.

Scats were routinely collected in winter during weekly track surveys on Rainy Lake, Kabetogama Lake and selected beaver drainages. Incidentally-found scats from the study areas supplemented small sample sizes. Scats were not collected on Namakan or Sand Point Lakes during winter.

All scats were washed over a 1-mm mesh sieve, air dried, individually packaged and catalogued. Because of an inherent bias with volume measurements in otter food habits studies (Knudsen and Hale 1968; Toweill 1974), only frequency of occurrence of prey items was recorded.

Prey remains were categorized as: fish (Osteichthyes); crayfish (Crustacea); bird (Aves); mammal (Mammalia); insect (Insecta); frog and toad (Amphibia); or snail and freshwater clam (Mollusca). Monthly sample sizes were small for many sampling sites because otters tend to vary their use of latrine sites (Reid 1984). Data were grouped into either summer (ice-free period) or winter (period with ice-cover).

## RESULTS AND DISCUSSION

### Capture and Biotelemetry

During 1,686 trap-nights between 19 April, 1985 and 1 November, 1986, 39 individual otters were captured. One otter was recaptured twice resulting in 41 captures or 41.1 trap-nights per otter (Table 1). Additionally, there were 11 known otter escapes, 47 incidental captures (including eight species of birds and mammals) and 38 sprung traps (Table 2).

Other studies in North America (Northcott and Slade 1976; Melquist and Hornocker 1983; Reid 1984; Woolington 1984; Polechla 1985) have averaged over 100 trap-nights per otter. The high trap success in this study may be due to: 1) a relatively high otter density; 2) an untrapped, therefore untrap-wise, otter population; and 3) Hancock traps being very effective for catching otters.

Trap success for otter was much higher during spring than fall ($x^2 = 36.0$, 1 df, $P < 0.001$), with males being captured more often in spring and females captured more often in fall ($x^2 = 4.48$, 1 df, $P < 0.05$). However, no significant difference existed between Rainy Lake and Namakan Reservoir ($x^2 = .115$, 1 df, $P > 0.50$) (Table 3).

Adult male otters traveled extensively during the spring mating season and were readily trapped during this time. Adult females, on the other hand, were captured more often in fall when family groups limited their activities to productive backwater bays. Of four family groups we attempted to trap, the adult female was usually captured rather than her juvenile offspring ($x^2 = 6.28$, 1 df, $P < 0.025$), likely because adult females tended to initiate "landing" at haul-out areas. This phenomenon has not been shown in other studies, but if true in a harvested population, it may be important for managers considering a fall trapping season for otters.

Table 1. Live-trapping results by season in VNP, Minnesota.

| SEASON | TRAP NIGHTS | OTTER CAPTURES | TRAP NIGHTS PER OTTER |
|---|---|---|---|
| SPRING 85 | 142 | 8 | 17.8 |
| FALL 85 | 707 | 8 | 88.4 |
| SPRING 86 | 164 | 14 | 11.7 |
| FALL 86 | 673 | 11 | 61.2 |
| TOTALS = | 1,686 | 41 | 41.1 |

Table 2. Incidental captures, sprung traps and otter escapes in 1,686 trap-nights in VNP, Minnesota.

| RESULT OF CLOSED TRAP | NUMBER OF OCCURRENCES |
|---|---|
| OTTER ESCAPE | 11 |
| BEAVER CAPTURE | 37 |
| SPRUNG BY BEAVER | 4 |
| SPRUNG BY MINK (*Mustela vison*) | 4 |
| RUFFED GROUSE (*Bonasa umbellus*) CAPTURE | 4 |
| SPRUNG BY WHITETAIL DEER (*Odocoileus virginianus*) | 3 |
| SPRUNG BY FISHERMAN | 2 |
| RED FOX (*Vulpes fulva*) CAPTURE | 1 |
| FISHER (*Mustela pennanti*) CAPTURE | 1 |
| SPRUNG BY BLACK BEAR (*Ursus americanus*) | 1 |
| MALLARD DUCK (*Anus platyrhynchos*) CAPTURE | 1 |
| COMMON FLICKER (*Colaptes auratus*) CAPTURE | 1 |
| GRAY JAY (*Perisoreus canadensis*) CAPTURE | 1 |
| RAVEN (*Corvus corax*) CAPTURE | 1 |
| SPRUNG BY MUSKRAT | 1 |
| UNKNOWN | 23 |
| TOTAL | 96 |

Table 3. Trapping success by water regime and season during 1,686 trap-nights in VNP, Minnesota.

| | RAINY LAKE | | | NAMAKAN RESERVOIR | | |
|---|---|---|---|---|---|---|
| SEASON | TRAP NIGHTS | OTTER CAP'S | TRAP NIGHTS PER OTTER | TRAP NIGHTS | OTTER CAP'S | TRAP NIGHTS PER OTTER |
| SPRING 85 | --- | - | ---- | 142 | 8 | 17.8 |
| FALL 85 | --- | - | ---- | 707 | 8 | 88.4 |
| SPRING 86 | 58 | 5 | 11.6 | 106 | 9 | 11.8 |
| FALL 86 | 477 | 7 | 68.1 | 196 | 4 | 49.0 |
| TOTALS = | 535 | 12 | 44.6 | 1151 | 29 | 39.7 |

We attempted to surgically implant radio transmitters in 26 otters. One surgery was aborted because the juvenile otter was too small; of 25 completed surgeries, 19 resulted in animals being successfully monitored for the study (Fig. 3). Three additional otters were successfully implanted but their radios malfunctioned. Within 17 days of release, two of the radio-implanted otters died from long-standing urinary infections that were likely exacerbated by stress from handling (see Physical Condition and Mortality Factors section). Another otter died within 10 days of release when its sutures pulled loose. Following this loss, the skin was sutured closed with a combination of "00" synthetic absorbable suture and Nexadand surgical adhesive placed at the closure of alternate stitches. Twenty successful surgeries were completed after adopting this procedure (Route unpubl. data).

## Demographic and Physical Characteristics

Of 42 otters handled, 3 (7%) were classified as juveniles, 14 (33%) were yearlings, and 25 (60%) were adults (Table 4 and Fig. 4). However, this age distribution is probably not representative of the true otter population in VNP because of sex-differential trap vulnerability (see capture results). Based on observations of ten different family groups, mean productivity was estimated at 2.6 young per breeding female. Melquist and Hornocker (1983) similarily estimated a mean productivity of 2.4 young per breeding female and Tabor and Wight (1977) estimated the mean number of young as 1.14 females (2.28 young assuming equal sex ratios). However, MDNR mean corpra lutea counts have ranged from 2.1 to 2.3 for female otters 1.5-2.5 years old and 2.2 to 2.3 for females over 2.5 years old (MDNR unpubl. data). The estimated young per female in VNP may be high because large family groups are likely more visible.

Sex ratios of the trapped population appeared to favor males in the adult age class (Table 5); however, they did not differ significantly from balanced ratios (combined juvenile and yearling, $x^2 = 0.059$, 1df, $P > 0.05$) (adult, $x^2 = 1.48$, 1df, $P > 0.10$) (all age classes, $x^2 = 0.381$, 1df, $P > 0.05$).

Overall, female otters were smaller in weight ($P < 0.0063$) and had a smaller zygomatic breadth ($P < 0.0349$) than males. Weights ranged from a 4.6 kg (10.1 lb) juvenile female to a 9.25 kg (20.4 lb) adult male (Table 6).

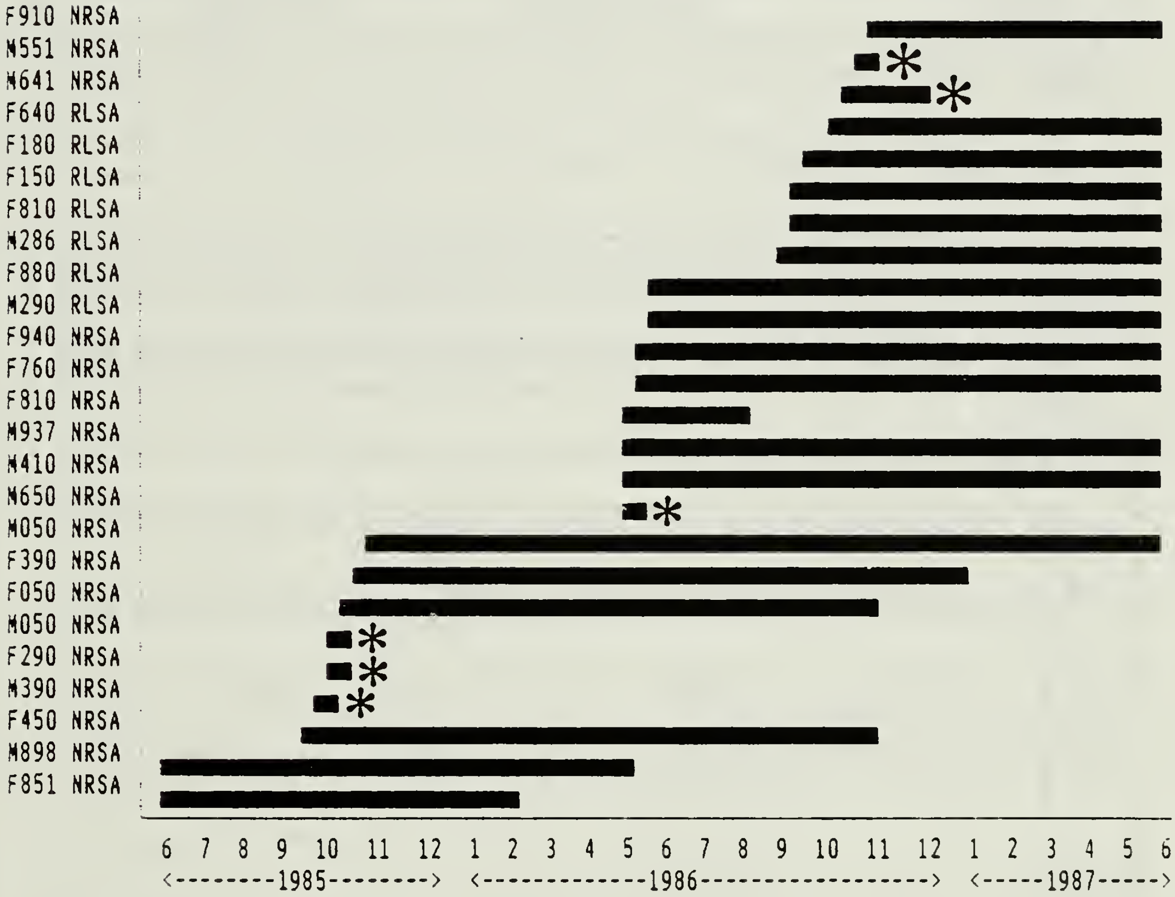


Fig. 3. Duration of radio-contact with 25 otters surgically implanted with radio telemetry devices in VNP, Minnesota, 1985-87. Six radio-telemetered otters ( * ) provided little information to the study due to short duration of contact. Otter tag number and the study area of each captured otter are on the vertical axis. Durations are denoted by year(s) and month(s) on the horizontal axis.

Table 4. Standard capture data on 42 otters handled in VNP, Minnesota, 1985-1987.

| CAP # | NAME | LAKE | CAPTURE DATE YY | MM | DD | EAR TG # RIGHT | LEFT | RADIOED ?? | EST AGE | SEX | WEIGHT (kg) | TOTAL LENGTH (cm) | ZYG (cm) | TAIL LENGTH (cm) | TOOTH WEAR | COND'N INDEX | REC TEMP (c) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | NO NAME | KAB | 85 | 5 | 2 | ---- | ---- | NO | ADT | M | 7.90 | 111.0 | 7.8 | 39.0 | EXT | GOOD | 40.5 |
| 2 | NO NAME | KAB | 85 | 5 | 12 | A144 | ---- | NO | ADT | F | 7.50 | 113.0 | 7.2 | 38.0 | EXT | FAIR | 38.5 |
| 3 | NO NAME | KAB | 85 | 5 | 16 | ---- | A145 | NO | ADT | M | 7.80 | 108.0 | 8.0 | 41.5 | MOD | GOOD | 36.6 |
| 4 | NO NAME | KAB | 85 | 5 | 16 | A147 | ---- | NO | ADT | M | 8.50 | 115.0 | 7.4 | 43.0 | MOD | GOOD | 38.6 |
| 5 | NO NAME | KAB | 85 | 5 | 20 | A197 | A193 | NO | YRL | M | 7.00 | 111.5 | 7.3 | 41.0 | MOD | FAIR | 38.8 |
| 6 | ROSEANN | KAB | 85 | 6 | 2 | ---- | A198 | YES | YRL | F | 7.25 | 111.0 | --- | 42.0 | LIT | GOOD | 38.2 |
| 7 | NO NAME | KAB | 85 | 6 | 3 | A199 | ---- | NO | YRL | M | 6.50 | 106.5 | 7.6 | 39.0 | MOD | GOOD | 39.1 |
| 8 | FRED | KAB | 85 | 6 | 5 | ---- | A141 | YES | ADT | M | 9.25 | 117.0 | 8.2 | 45.5 | MOD | GOOD | 38.9 |
| 9 | CANDY | KAB | 85 | 9 | 15 | A129 | A454 | YES | ADT | F | 7.70 | 109.5 | 8.2 | 40.0 | LIT | GOOD | 37.3 |
| 10 | NO NAME | KAB | 85 | 9 | 26 | A374 | ---- | NO | JUV | F | 4.60 | 90.0 | 6.8 | 30.0 | LIT | GOOD | 36.4 |
| 11 | OSCAR | KAB | 85 | 9 | 27 | A372 | A371 | YES | ADT | M | 7.50 | 106.5 | 8.0 | 38.0 | MOD | GOOD | 37.7 |
| 12 | NO NAME | KAB | 85 | 10 | 5 | A390 | ---- | YES | YRL | F | 6.20 | 108.5 | 7.4 | 41.5 | LIT | GOOD | 38.9 |
| 13 | NO NAME | KAB | 85 | 10 | 8 | A375 | A385 | YES | YRL | F | 6.62 | 105.5 | 7.7 | 36.0 | MOD | GOOD | 35.1 |
| 14 | FREEDOM | KAB | 85 | 10 | 23 | A350 | A386 | YES | ADT | M | 8.12 | 113.5 | 8.1 | 40.0 | MOD | GOOD | 39.0 |
| 15 | FRECKLES | KAB | 85 | 10 | 24 | A378 | A379 | YES | ADT | F | 6.80 | 111.0 | 7.5 | 42.0 | MOD | GOOD | 38.1 |
| 16 | THE WOLF | KAB | 85 | 10 | 31 | A281 | A229 | YES | YRL | M | 7.75 | 113.0 | 7.5 | 40.0 | MOD | GOOD | 39.3 |
| 17 | NO NAME | KAB | 86 | 4 | 30 | ---- | ---- | YES | ADT | M | 9.00 | 109.8 | 7.8 | 40.0 | MOD | GOOD | ---- |
| 18 | NO NAME | KAB | 86 | 5 | 1 | A223 | ---- | NO | ADT | M | 8.60 | 111.5 | 7.6 | 41.0 | EXT | GOOD | 38.9 |
| 19 | 410 | KAB | 86 | 5 | 1 | ---- | A288 | YES | ADT | M | 9.10 | 116.3 | 8.1 | 41.0 | EXT | GOOD | 36.1 |
| 20 | NO NAME | KAB | 86 | 5 | 2 | A207 | ---- | NO | YRL | M | 6.75 | 104.0 | 7.5 | 35.0 | LIT | GOOD | ---- |
| 21 | NO NAME | KAB | 86 | 5 | 3 | A285 | ---- | NO | ADT | M | 8.50 | 119.0 | 8.0 | 42.0 | LIT | GOOD | ---- |
| 22 | SCAR FACE | KAB | 86 | 5 | 3 | ---- | A357 | YES | ADT | M | 9.10 | 102.0 | 8.0 | 42.0 | MOD | GOOD | 41.1 |
| 23 | 810 | KAB | 86 | 5 | 5 | A204 | ---- | YES | YRL | F | 6.50 | 105.0 | 7.3 | 39.0 | MOD | GOOD | 41.1 |
| 24 | 760 | KAB | 86 | 5 | 6 | ---- | A358 | YES | YRL | F | 6.30 | 108.0 | 7.9 | 40.0 | LIT | GOOD | 39.6 |
| 25 | TICK | KAB | 86 | 5 | 9 | A221 | ---- | YES | ADT | F | 7.20 | 115.0 | 7.5 | 44.0 | MOD | GOOD | 38.9 |
| 26 | NO NAME | KAB | 86 | 5 | 17 | A213 | A222 | NO | ADT | F | 7.25 | 109.0 | 7.5 | 39.0 | EXT | GOOD | ---- |
| 27 | NO NAME | RAI | 86 | 5 | 21 | A232 | ---- | NO | YRL | M | 6.00 | 103.0 | 7.0 | 37.0 | MOD | GOOD | ---- |
| 28 | NO NAME | RAI | 86 | 5 | 24 | ---- | A240 | NO | ADT | M | 8.25 | 105.0 | 7.9 | 40.0 | MOD | GOOD | ---- |
| 29 | 290 | RAI | 86 | 5 | 24 | A363 | ---- | YES | YRL | M | 6.80 | 105.0 | 7.6 | 35.0 | LIT | GOOD | ---- |
| 30 | NO NAME | RAI | 86 | 5 | 25 | ---- | A230 | NO | ADT | M | 8.30 | 113.0 | 7.9 | 40.0 | MOD | GOOD | ---- |
| 31 | 880 | RAI | 86 | 5 | 25 | A234 | ---- | YES | ADT | F | 8.10 | ----- | 8.0 | 44.0 | MOD | GOOD | 40.7 |
| 32 | ALFRED | RAI | 86 | 9 | 9 | A243 | A233 | YES | YRL | M | 7.00 | 106.0 | 7.1 | 39.0 | MOD | GOOD | 39.2 |
| 33 | NANCY | RAI | 86 | 9 | 18 | A237 | A355 | YES | YRL | F | 7.00 | 106.0 | 7.5 | 38.0 | MOD | GOOD | 38.7 |
| 34 | SARAH | RAI | 86 | 9 | 18 | A246 | A393 | YES | ADT | F | 7.00 | 107.0 | 7.5 | 40.0 | MOD | GOOD | 40.8 |
| 35 | VELCRO | RAI | 86 | 9 | 20 | A311 | A319 | YES | ADT | F | 7.25 | 110.5 | 7.4 | 42.0 | EXT | GOOD | 38.9 |
| 36 | SHARI | RAI | 86 | 10 | 6 | A352 | A391 | YES | YRL | F | 6.50 | 105.0 | 7.3 | 37.0 | LIT | GOOD | 38.3 |
| 37 | 641 | KAB | 86 | 10 | 17 | A238 | ---- | YES | JUV | M | 5.25 | 98.5 | 7.0 | 37.0 | LIT | GOOD | 39.1 |
| 38 | GRAMPS | KAB | 86 | 10 | 22 | ---- | ---- | NO | ADT | M | 6.75 | 111.0 | 8.0 | 41.0 | EXT | POOR | 39.4 |
| 39 | 551 | KAB | 86 | 10 | 22 | ---- | A275 | YES | ADT | M | 8.75 | 116.0 | 8.0 | 44.5 | MOD | GOOD | 39.7 |
| 40 | 910 | KAB | 86 | 10 | 26 | A205 | A360 | YES | ADT | F | 7.50 | 108.0 | 7.5 | 43.0 | MOD | GOOD | 39.4 |
| 41 | ONE EYE | KAB | 86 | 10 | 31 | A307 | A239 | NO | ADT | F | 8.50 | 102.0 | 7.4 | 43.0 | EXT | GOOD | ---- |
| 42 | NO NAME | KAB | 86 | 10 | 31 | ---- | A354 | NO | JUV | F | 5.75 | 95.3 | 6.8 | 30.6 | LIT | GOOD | ---- |

Note: Three otters captured incidentally during a simultaneously-running study on beaver (D. Smith, Mich. Tech. Univ., pers. commun.)

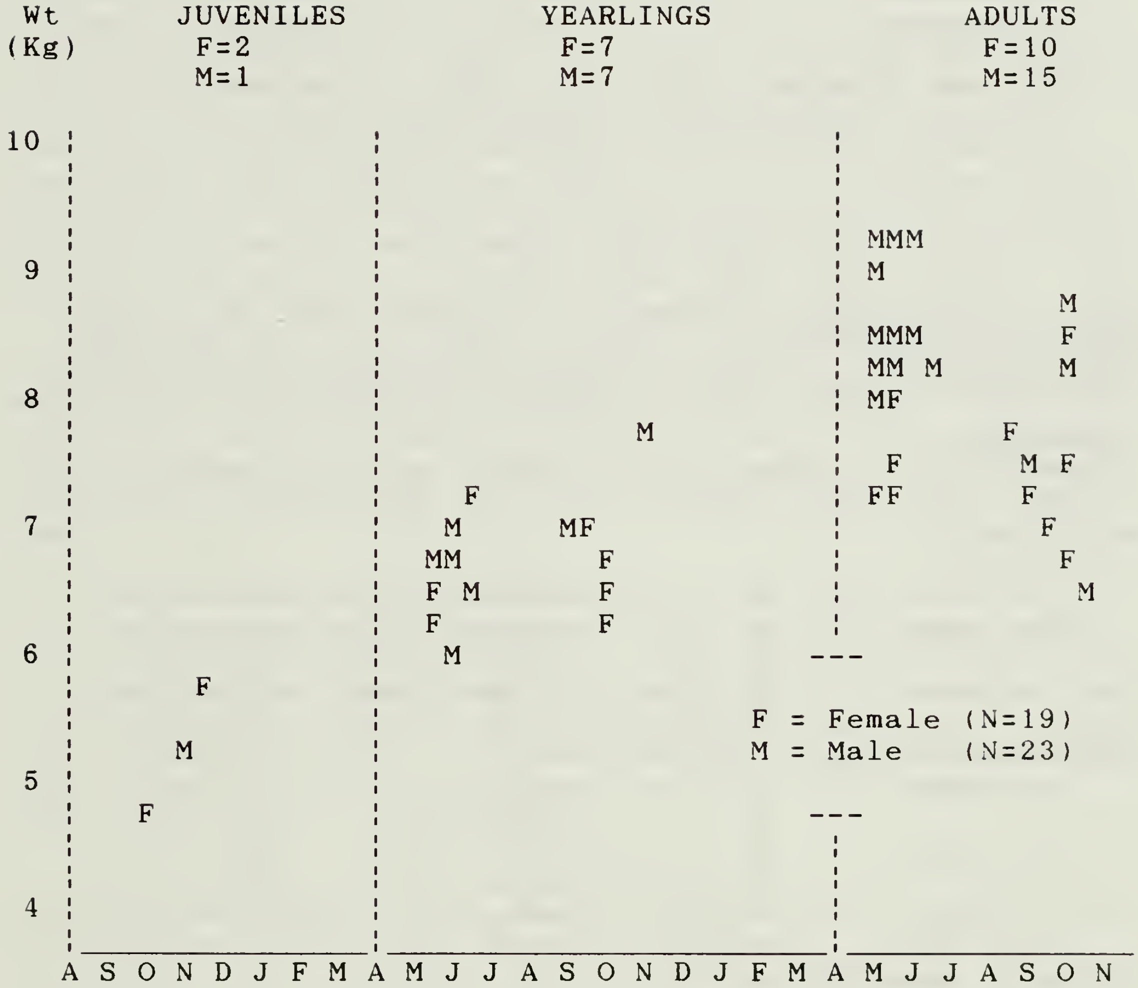


Fig. 4. Weights (kg) and month in which 42 otter were live-captured in VNP, Minnesota 1985-86. Vertical line denotes approximate date of spring birthing.

Table 5. Sex ratios of live-captured otters in VNP, Minnesota 1985-86.

| AGE CLASS | MALES | FEMALES | MALE:FEMALE RATIO |
|---|---|---|---|
| Juveniles | 1 | 2 | 50:100 |
| Yearlings | 7 | 7 | 100:100 |
| Adults | 15 | 10 | 150:100 |
| All age classes | 23 | 19 | 121:100 |

Table 6. Standard measurements of otters captured in VNP, Minnesota 1985-86.

| PARAMETER /AGE | SEX | N | AVE | S.D. | RANGE |
|---|---|---|---|---|---|
| WEIGHT (kg) | | | | | |
| Juveniles | F | 2 | 5.18 | 0.81 | 4.60-5.75 |
| | M | 1 | 5.25 | ---- | --------- |
| Yearlings | F | 7 | 6.62 | 0.38 | 6.20-7.25 |
| | M | 7 | 6.83 | 0.53 | 6.00-7.75 |
| Adults | F | 10 | 7.48 | 0.51 | 6.80-8.50 |
| | M | 15 | 8.36 | 0.68 | 6.75-9.25 |
| TOTAL LENGTH (cm) | | | | | |
| Juveniles | F | 2 | 92.7 | 3.7 | 90.0-95.3 |
| | M | 1 | 98.5 | --- | --------- |
| Yearlings | F | 7 | 107.0 | 2.3 | 105.0-111.0 |
| | M | 7 | 107.0 | 3.8 | 103.0-113.0 |
| Adults | F | 10 | 109.4 | 3.7 | 102.0-113.0 |
| | M | 15 | 111.6 | 4.8 | 102.0-119.0 |
| ZYGOMATIC BREADTH (cm) | | | | | |
| Juveniles | F | 2 | 6.8 | 0.0 | 6.8-6.8 |
| | M | 1 | 7.0 | --- | ------- |
| Yearlings | F | 7 | 7.5 | 0.2 | 7.3-7.9 |
| | M | 7 | 7.4 | 0.2 | 7.0-7.6 |
| Adults | F | 10 | 7.6 | 0.3 | 7.2-8.2 |
| | M | 15 | 7.9 | 0.2 | 7.4-8.2 |

## Physical Condition and Mortality Factors

Of the 42 otters handled, 39 (93%) were determined to be in good physical condition. Two otters were considered in fair condition based on the prominence of their vertebral processes but one was a lactating female and may have been stressed from caring for young. A third otter, listed in poor condition, died 12 hours after being found in the trap. The carcass was sent to the U. S. Fish and Wildlife (FWS) Service's National Wildlife Health Lab (NWHL) in Madison, Wisconsin, for necropsy. Results indicate the animal was in poor nutritional condition, dehydrated, and stressed prior to capture. The general diagnosis was adrenal failure with capture stress and anesthesia likely hastening death (R.K. Stroud, DVM and P.A. Gullett, DVM, NWHL, pers. comm.).

Additionally, two otters, listed in good condition and subsequently radioed, died within 17 days of release. Both were diagnosed by NWHL as having chronic cystitis (urinary infection) prior to capture; however, stress from capture and radio implantation probably contributed to their death also (R.K. Stroud, DVM and P.A. Gullett, DVM, NWHL, pers. comm.).

Skeletal remains of two unmarked otter were found while hiking lake shores during summer. The intact remains of one 2 or 3-year-old female showed no sign of being preyed on or scavenged as the bones were still articulate. Cause of death was undetermined. The scattered skeletal remains of a second 1 or 2-year-old otter of unknown sex was found in a remote area. The bones were well chewed but the exact cause of death could not be determined.

There are few reports of natural mortality for wild otters, mainly due to the remote regions they occupy, their low abundance, and their secretive behavior. Of the nine documented otter mortalities in Central Idaho, one was attributed to shifting talus rocks (Melquist and Hornocker 1983).

On 2 September 1986, we documented the death of a radioed female yearling otter (F811), presumably by wolves (Canis lupus). This otter had been located alive 24 hours prior to the carcass being recovered. Fresh wolf sign was found at the site and a resident pack with pups was known to range in the area (personal observation). The carcass was sent to NWHL and they reported the animal was in good physical condition with no sign of infectious disease or other debilitations. They observed traumatic lesions on the back and pelvis that would be "consistent with those expected to be produced by a large predator such as a wolf" (R.K. Stroud, DVM and P.A. Gullett, DVM, NWHL, pers. comm.).

This documentation of an otter being killed by wolves is the first we are aware of; although, coyotes (C. latrans) have reportedly killed young otters (Grinnell et al. 1937). Even so, based on our data and the literature on wolf food habits in the vicinity of VNP (Fisher 1975; Hardwig 1978; Fuller 1988), we expect that wolf predation on otters is rare.

Otters were sometimes infested with the beaver nest beetle (Leptinillus validus) and/or the beaver parasite beetle (Platypsyllus castoris). Both beetles are scavengers that feed on sloughing skin and are not considered stressful to the host (G. Parsons, OSU Entomology Dept., Corvallis, Ore., pers. comm.). These beetles are probably picked up by otters when using beaver lodges as resting sites.

Occasionally, unidentified tapeworm (Order Pseudophylidea) proglottids were found in scats. Otters probably ingest tapeworms along with the host (e.g. fish); however, several species of internal parasites, including tapeworms, have been documented in otter (Lauhachinda 1978).

Mercury contamination is potentially a problem in VNP otters since high levels have been reported in fish and common loons (Gavia immer) from the area (Minn. Pollution Control Agency (MPCA), unpubl. data). Fish concentrate mercury as much as 4,800 times that of the water around them (Hoffman and Curnow 1979). Otters, like other predators high on the aquatic food chain, accumulate mercury and since otters are resident predators they serve as good biological indicators of contamination (Kucera 1983). Fur samples from 18 live-captured otters were sent to the MPCA for analysis of mercury contamination. Results of only five of these samples are available at this time, but they show significant concentrations of mercury, especially those from Rainy Lake (Table 7).

Table 7. Mercury concentrations in fur samples from live-captured otter in VNP, Minnesota.

| CAP # | WEIGHT (kg) | LAKE | SEX | EST AGE | MERCURY (ppm) |
|---|---|---|---|---|---|
| 22 | 9.10 | KAB | MALE | ADT | 7.5 |
| 28 | 8.25 | RAINY | FEMALE | ADT | 28.0 |
| 29 | 6.80 | RAINY | MALE | YRL | 28.0 |
| 30 | 8.30 | RAINY | MALE | ADT | 56.0 |
| 31 | 8.10 | RAINY | FEMALE | ADT | 75.0 |

Capture # refers to Table 4.

Mercury concentrations in otter fur from nonindustrialized watersheds in Wisconsin averaged 5.3 ppm (Sheffy and Amant 1982). Sheffy and Amant (1982) found mercury levels to be consistantly higher in fur and were correlated with levels in soft tissues by a ratio of 2.5 to 1. Otters experimentally killed by methylmercury died at concentrations of 33.4 ppm in liver and 39.2 ppm in kidney tissue (O'Connor and Nielsen 1981). Although O'Connor and Nielson did not test for mercury in fur, using a ratio of 2.5 to 1 (Sheffy and Amant 1982), otters with mercury concentrations of 83.5 ppm in fur could be near death.

Otter capture number 31 (Table 7), with a fur mercury concentration of 75 ppm, is the highest reported for wild otter in North America and may be approaching a lethal limit. Effects of sublethal concentrations of a toxic substance are difficult to measure (Wren 1985) but other authors have attributed environmental pollution, including mercury contamination, to recent declines in otter populations (Erlinge 1972; Mason et al. 1986).

## Home Range

Efforts to radio-track river otter resulted in 19 otters being monitored for a total 1,098 locations (Table 8). Frequency of location depended on sex, season, and survival (males were more difficult to locate because of large home ranges). There is a paucity of comparable data in the literature, so that in spite of small sample sizes, these data are useful for assessing water levels as well as our efforts to trap, radio-locate, observe and ultimately estimate the abundance of otter.

Table 8. Frequency radioed otters were located during periods of no ice, with ice and during freeze-up or thaw in VNP, Minnesota, 1985-87.

| | | | | NUMBER OF LOCATIONS [c] | | | |
|---|---|---|---|---|---|---|---|
| OTTER | SEX | AGE [a] | LAKE [b] | NO ICE | WITH ICE | FREEZE /THAW | TOTAL |
| 851 | F | YRL | NR | 98 | 20 | 0 | 118 |
| 898 | M | ADT | NR | 28 | 33 | 4 | 65 |
| 450 | F | ADT | NR | 42/36 | 37 | 8 | 123 |
| 390 | F | ADT | NR | 7/51 | 46/3 | 7 | 114 |
| 380 | M | ADT | NR | 7/16 | 44 | 5 | 72 |
| 050 | M | YRL | NR | 17 | 45 | 4 | 66 |
| 811 | F | YRL | NR | 22 | -- | - | 22 |
| 940 | F | ADT | NR | 38 | 33 | 3 | 74 |
| 290 | M | YRL | RL | 40 | 23 | 1 | 64 |
| 880 | F | ADT | RL | 40 | 22 | 1 | 63 |
| 760 | F | YRL | NR | 33 | 32 | 2 | 67 |
| 410 | M | ADT | NR | 27 | 25 | 1 | 53 |
| 180 | F | ADT | RL | 22 | 24 | 2 | 48 |
| 286 | M | YRL | RL | 12 | 21 | 0 | 33 |
| 150 | F | ADT | RL | 8 | 20 | 0 | 28 |
| 910 | F | ADT | NR | 5 | 16 | 2 | 23 |
| 937 | M | ADT | NR/RL | 9 | 6 | 0 | 15 |
| 810 | F | YRL | RL | 10 | 18 | 0 | 28 |
| 641 | F | YRL | RL | 3 | 19 | 0 | 22 |
| TOTALS= | F=12 | ADT=11 | NR=11.5 | 571 | 487 | 40 | 1098 |
| | M= 7 | YRL= 8 | RA= 7.5 | | | | |

a Age at time of capture, ADT = adult, YRL = yearling.

b NR = Namakan Reservoir, RL = Rainy Lake.

c Numbers separated by a slash denote 2 different years.

Home range characteristics varied considerably between individuals, sexes and seasons (Tables 9 and 10). Area varied from a low of 0.64 $km^2$ for yearling F640 ("F" = female) during winter on RLSA, to a high of 29.13 $km^2$ for adult M380 ("M" = male) during summer on NRSA. Use of large lakes, inland lakes, ponds and creeks also varied with individuals and seasons. For example, adult M898 and adult F150 with yearling F640 spent their entire winters in ponds and beaver drainages (Tables 9 and 10).

Overall, adult males had larger summer home range areas ($t = 7.28$, 9 df, $P < 0.01$) with more total shoreline available ($t = 6.12$, 9 df, $P < 0.01$) than did adult females. However, during winter these same home range parameters did not differ significantly between sexes ($P > 0.05$). Summer home range area ($t = 6.44$, 3 df, $P < 0.005$) and total shoreline ($t = 5.69$, 3 df, $P < 0.005$) of individual adult males were significantly larger than their respective winter home ranges, but the same was not true for adult females (area: $t = 1.22$, 5 df, $P > 0.05$) (shore: $t = 1.12$, 5 df, $P > 0.05$). No adult males were radiomonitored on RLSA; however, in comparing adult females between study areas, we found no significant differences in area ($t = 0.93$, 5 df, $P > 0.10$) or total shoreline ($t = 0.06$, 5 df, $P > 0.10$) within winter home ranges. Insufficient data existed to test between female summer home ranges.

Home ranges of all known family groups ( N = 10, 3 marked and 7 unmarked) were associated with backwater bays during summer. Shallow bays provide a quiet environment for raising young and an ample supply of crayfish and slow-moving fish that comprise the bulk of an otter's diet (Lagler and Ostenson 1942; Hamilton 1961; Sheldon and Toll 1964; this study). Melquist and Hornocker (1983) observed similar associations of family groups with backwater bays.

Radiomonitored family groups and single radiomonitored females that utilized shallow bays during summer showed a marked shift in their home range towards deeper water in winter. During summer, F851, F450, F390, F910 and F180 occupied home ranges that were mainly within shallow bays. By February they were utilizing deeper water areas, some within but mostly outside of, their summer range. This shift was most pronounced for adults F390 and F450 on NRSA (Fig. 5). During summer these two females, each with two juvenile offspring, occupied nonoverlapping home ranges in backwater bays. Through initial freeze-up and until 30 January both continued to range within their respective "summer ranges".

However, between locations on 30 January and 3 February, both had moved to new areas well outside of their summer range. F450 moved through F390's home range and for the remainder of the winter their home ranges overlapped considerably. Similar shifts occurred for F910 and F851 on NRSA and for F180 on RLSA (Fig. 6). Two of six females radioed on NRSA did not exibited this shift; adult F940 occupied a summer range that was already in deep water, and yearling F760 spent most of the winter in an inland pond with stable water levels. Three of four radioed females on RLSA did not shift home ranges to deeper water; however, adult F880 already occupied a home range with considerable deep water, and adult F150 and yearling F640 spent the entire winter together in inland beaver ponds.

The observed shifts from shallow bays to deeper water could certainly be expected. As water is drawn down over the winter, ice slowly collapses onto the bottom substrates of shallow bays (Kraft 1988). Small under-ice rivulets provide some access, but for the most part these bays are unavailable for otters and their prey. Although this shift was evident for one female otter on Rainy Lake, we could expect it to be more pronounced in otters inhabiting the Namakan Reservoir since it experiences a greater winter draw-down (Fig. 2).

Table 9. Winter home range parameters of radioed otters on Namakan Reservoir and Rainy Lake, VNP, Minnesota.

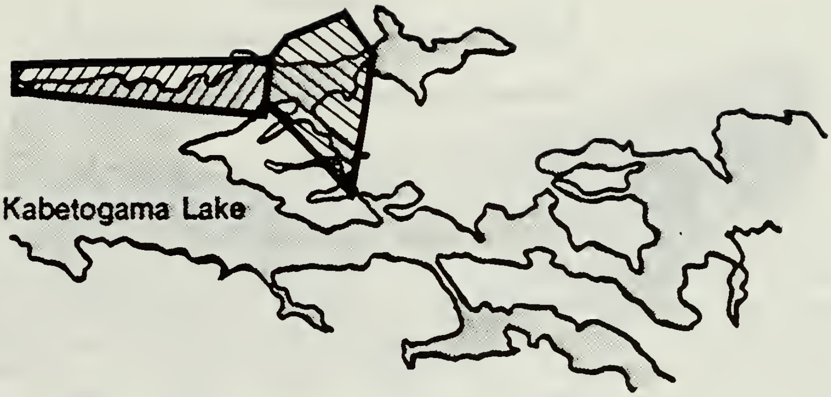
| | | | | | SHORELINE LENGTH (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| OTTER[a] | AGE | YR | N | AREA ($km^2$) | LARGE LAKES | INLAND LAKES | PONDS | CREEKS | TOTAL |
| NAMAKAN: | | | | | | | | | |
| F390 | ADT | 85 | 46 | 13.64 | 15.23 | 0.00 | 2.21 | 2.32 | 19.76 |
| F450 | ADT | 85 | 37 | 6.62 | 17.80 | 1.08 | 1.67 | 0.83 | 21.38 |
| F851 | YRL | 85 | 20 | 2.73 | 7.68 | 0.00 | 0.00 | 0.00 | 7.68 |
| F910 | ADT | 86 | 16 | 4.67 | 17.17 | 0.00 | 0.00 | 0.00 | 17.17 |
| F940 | ADT | 86 | 33 | 2.94 | 1.79 | 0.00 | 0.00 | 0.00 | 1.79 |
| F760 | YRL | 86 | 32 | 0.71 | 2.18 | 0.00 | 0.69 | 0.14 | 3.01 |
| | AVE = | | 31 | 5.22 | 10.31 | 0.18 | 0.76 | 0.55 | 11.80 |
| | S.D.= | | 10 | 4.18 | 6.75 | 0.40 | 0.88 | 0.85 | 7.94 |
| M898 | ADT | 85 | 33 | 6.60 | 0.00 | 1.12 | 10.76 | 6.64 | 18.52 |
| M050 | ADT | 85 | 45 | 8.20 | 19.06 | 0.00 | 1.17 | 0.88 | 21.11 |
| M380 | ADT | 85 | 44 | 9.23 | 23.65 | 0.00 | 0.69 | 1.95 | 26.29 |
| M410 | ADT | 86 | 25 | 6.29 | 20.78 | 0.00 | 0.00 | 0.12 | 20.90 |
| | AVE = | | 37 | 7.58 | 15.87 | 0.28 | 3.16 | 2.40 | 21.71 |
| | S.D.= | | 8 | 1.20 | 9.31 | 0.48 | 4.41 | 2.53 | 2.84 |
| RAINY: | | | | | | | | | |
| F150 | ADT | 86 | 20 | 1.19 | 0.00 | 1.82 | 2.44 | 0.00 | 4.26 |
| F640 | YRL | 86 | 19 | 0.64 | 0.00 | 0.25 | 2.04 | 0.00 | 2.29 |
| F810 | YRL | 86 | 18 | 5.41 | 8.58 | 2.60 | 4.61 | 0.91 | 16.70 |
| F880 | ADT | 86 | 22 | 6.30 | 20.52 | 0.00 | 3.01 | 1.34 | 24.87 |
| F180 | ADT | 86 | 24 | 4.86 | 17.25 | 0.00 | 0.00 | 0.00 | 17.25 |
| | AVE = | | 21 | 3.68 | 9.27 | 0.93 | 2.42 | 0.45 | 13.07 |
| | S.D.= | | 2 | 2.31 | 8.52 | 1.07 | 1.49 | 0.57 | 8.53 |
| M290 | YRL | 86 | 23 | 2.13 | 7.83 | 0.00 | 0.87 | 1.33 | 10.03 |
| M286 | YRL | 86 | 21 | 4.04 | 13.88 | 0.00 | 2.20 | 1.37 | 17.45 |
| | AVE = | | 22 | 3.09 | 10.86 | 0.00 | 1.54 | 1.35 | 13.74 |
| | S.D.= | | 1 | 0.95 | 3.03 | 0.00 | 0.66 | 0.02 | 3.71 |

a = "F"=female "M"=male.

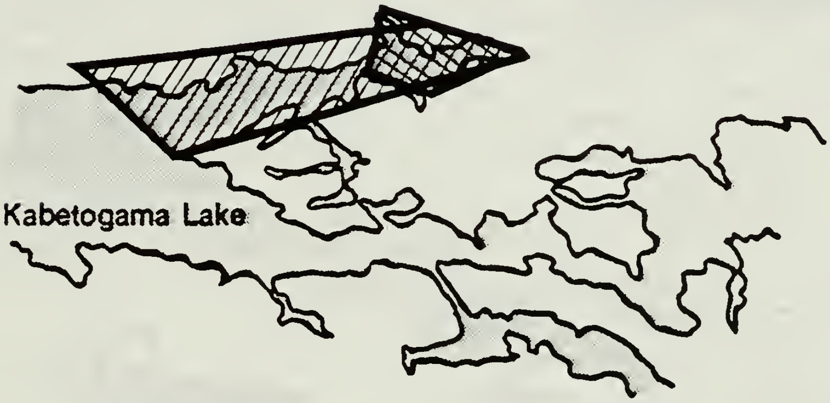
Table 10. Summer home range parameters of radioed otters on Namakan Reservoir and Rainy Lake, VNP, Minnesota.

| | | | | | SHORELINE LENGTH (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| OTTER[a] | AGE | YR | N | AREA (km²) | LARGE LAKES | INLAND LAKES | PONDS | CREEKS | TOTAL |
| NAMAKAN: | | | | | | | | | |
| F450 | ADT | 85 | 42 | 2.03 | 8.20 | 1.16 | 0.00 | 0.49 | 9.85 |
| F390 | ADT | 86 | 51 | 1.50 | 4.60 | 0.00 | 0.00 | 0.00 | 4.60 |
| F851 | YRL | 85 | 98 | 3.17 | 10.82 | 0.00 | 0.00 | 0.00 | 10.82 |
| F910 | ADT | 86 | 14 | 1.74 | 6.81 | 0.00 | 0.00 | 0.00 | 6.81 |
| F940 | ADT | 86 | 38 | 3.04 | 8.75 | 0.00 | 0.00 | 0.00 | 8.75 |
| F810 | YRL | 86 | 10 | 3.20 | 3.20 | 4.15 | 2.30 | 0.59 | 10.24 |
| F760 | YRL | 86 | 33 | 5.52 | 15.93 | 1.25 | 0.69 | 0.50 | 18.37 |
| | AVE = | | 41 | 2.89 | 8.33 | 0.94 | 0.43 | 0.23 | 9.92 |
| | S.D.= | | 27 | 1.26 | 3.90 | 1.41 | 0.80 | 0.26 | 3.99 |
| M898 | ADT | 85 | 28 | 20.24 | 32.59 | 0.00 | 13.33 | 12.09 | 58.01 |
| M050 | ADT | 86 | 17 | 19.35 | 36.60 | 5.35 | 5.19 | 4.81 | 51.95 |
| M380 | ADT | 86 | 16 | 29.13 | 29.88 | 4.66 | 8.92 | 12.20 | 55.66 |
| M410 | ADT | 86 | 27 | 16.80 | 24.20 | 5.06 | 2.91 | 3.86 | 36.03 |
| | AVE = | | 22 | 21.38 | 30.82 | 3.77 | 7.59 | 8.24 | 50.41 |
| | S.D.= | | 6 | 4.65 | 4.51 | 2.19 | 3.95 | 3.92 | 8.58 |
| RAINY: | | | | | | | | | |
| F880 | ADT | 86 | 40 | 7.91 | 25.17 | 0.00 | 2.28 | 2.11 | 29.56 |
| F180 | ADT | 86 | 22 | 4.54 | 15.66 | 0.00 | 1.44 | 0.00 | 17.10 |
| | AVE = | | 31 | 6.23 | 20.42 | 0.00 | 1.86 | 1.06 | 23.33 |
| | S.D.= | | 9 | 1.69 | 4.76 | 0.00 | 0.42 | 1.06 | 6.23 |
| M290 | YRL | 86 | 40 | 1.82 | 4.95 | 0.00 | 0.37 | 0.00 | 5.32 |
| M286 | YRL | 86 | 12 | 2.89 | 3.72 | 2.36 | 2.93 | 1.81 | 10.82 |
| | AVE = | | 26 | 2.36 | 4.34 | 1.18 | 1.65 | 0.91 | 8.07 |
| | S.D.= | | 14 | 0.53 | 0.62 | 1.18 | 1.28 | 0.90 | 2.75 |

a = "F"=female "M"=male.



A. Seasonal home range shift of F390.



B. Seasonal home range shift of F450.

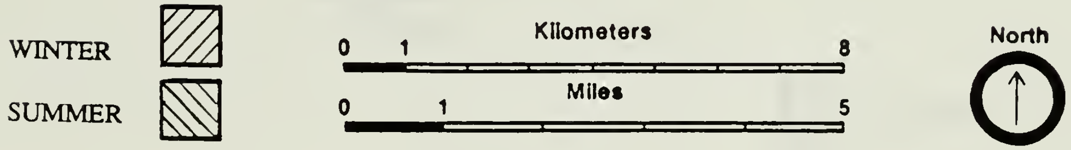


Fig. 5. Seasonal home range shift for radiomonitored females F390 (A) and F450 (B). F390 and F450 occupied nonoverlapping summer home ranges but with lowering water levels during winter, home ranges shifted towards deeper water where their ranges overlapped.

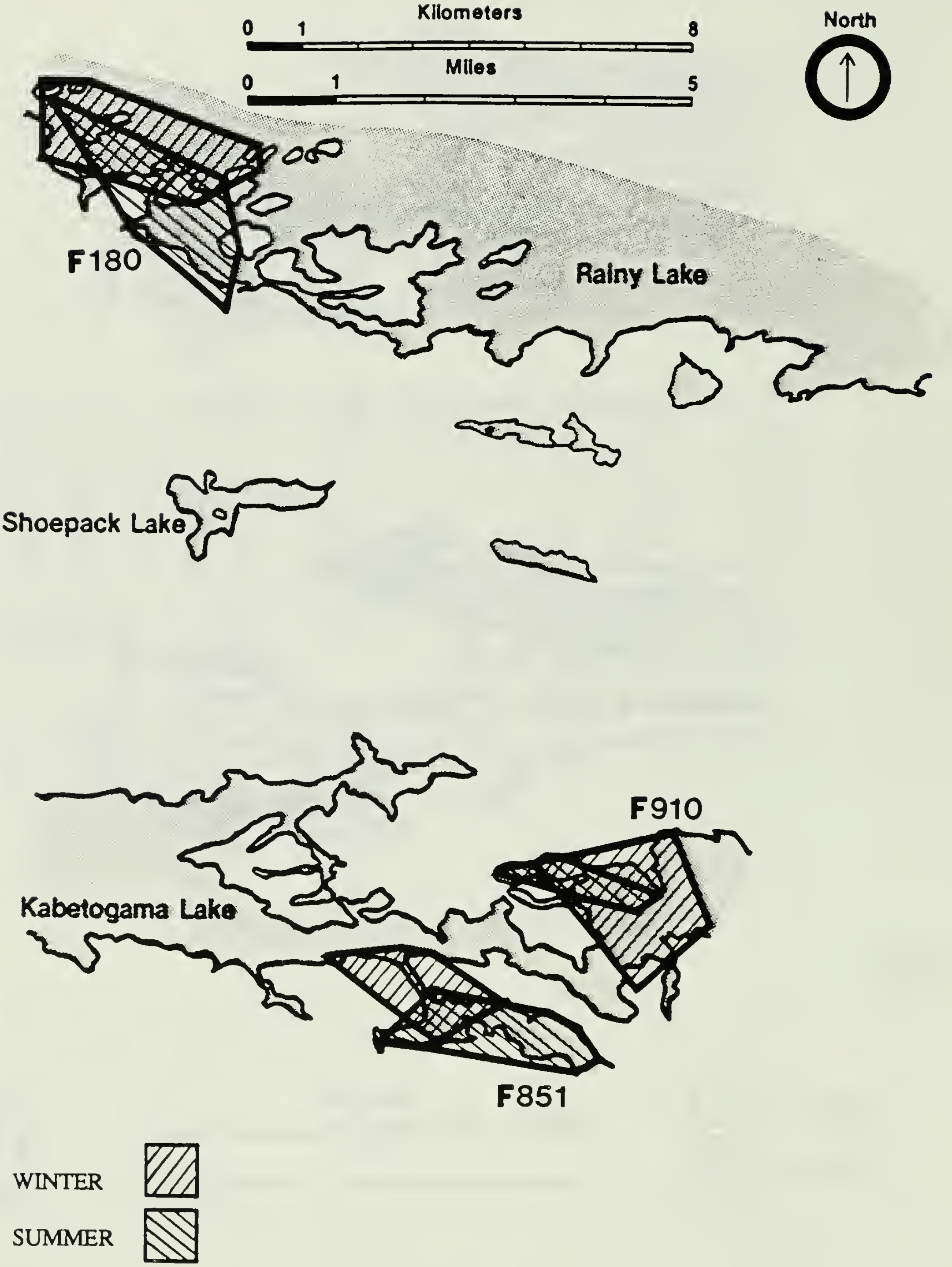


Fig. 6. Summer to winter home range shifts for female otters F851 and F910 on NRSA and F180 on RLSA.

## Movement Patterns

The longest straight-line distance recorded between consecutive-day locations was 9.3 km by adult M898 in April. During the spring mating season (March through April), adult males frequently traveled to the extreme ends of their home range and consequently their average distance between consecutive locations were double those of other seasons. By contrast, the average straight-line distance between consecutive locations for adult females varied little between seasons (Table 11).

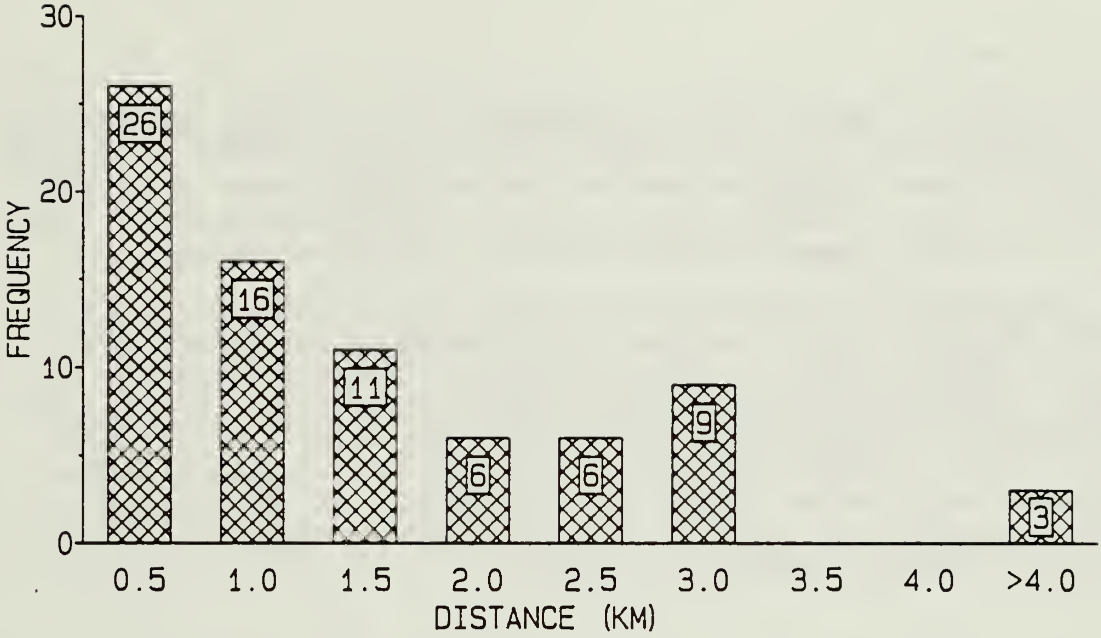
Otters moved freely between the large lakes and adjacent inland lakes and ponds in summer. While ice-cover did not prevent movement between water bodies, it appeared to limit these movements in winter. While some otters stayed mainly on the large lakes, others moved to inland waters and made little or no use of the large lakes (Tables 9 and 10). Our limited data does not reflect a difference in this tendency between sexes or between the two study areas.

During winter otters were located within 1 km of the previous day's location during 55% (N=77) of the locations and within 3 km during 96% of the locations (Fig 7).

Table 11. Distance between consecutive-day locations during spring, summer, fall and winter of 19 radioed otters from VNP, Minnesota.

| | | SPRING | SUMMER | FALL | WINTER |
|---|---|---|---|---|---|
| ADULT FEMALES: | NUM= | 24 | 14 | 67 | 44 |
| (N = 8) | AVE= | 1.2 | 1.4 | 1.1 | 1.0 |
| | S.D= | 1.0 | 1.1 | 0.8 | 1.1 |
| | RANGE= | 0.0-3.4 | 0.0-4.4 | 0.0-3.8 | 0.0-6.4 |
| ADULT MALES: | NUM= | 12 | 3 | 6 | 36 |
| (N = 5) | AVE= | 3.4 | 2.3 | 3.1 | 1.2 |
| | S.D= | 2.5 | 0.9 | 1.3 | 1.1 |
| | RANGE= | 0.9-9.3 | 1.2-2.9 | 1.2-4.6 | 0.0-4.5 |
| YEARLING MALES: | NUM= | 2 | 1 | 30 | 11 |
| (N = 2) | AVE= | 0.6 | 0.8 | 1.0 | 1.8 |
| | S.D= | 0.3 | --- | 0.7 | 1.1 |
| | RANGE= | 0.4-0.8 | 0.8-0.8 | 0.0-2.3 | 0.0-2.9 |
| YEARLING FEMALES: | NUM= | 0 | 25 | 28 | 11 |
| (N = 4) | AVE= | --- | 1.2 | 0.6 | 0.7 |
| | S.D= | --- | 0.7 | 0.7 | 0.9 |
| | RANGE= | --- | 0.4-3.0 | 0.0-2.0 | 0.0-2.8 |

SPRING = ice-out to 31 May; SUMMER = 1 June to 31 August. FALL = 1 September to ice-up. WINTER = with ice cover.



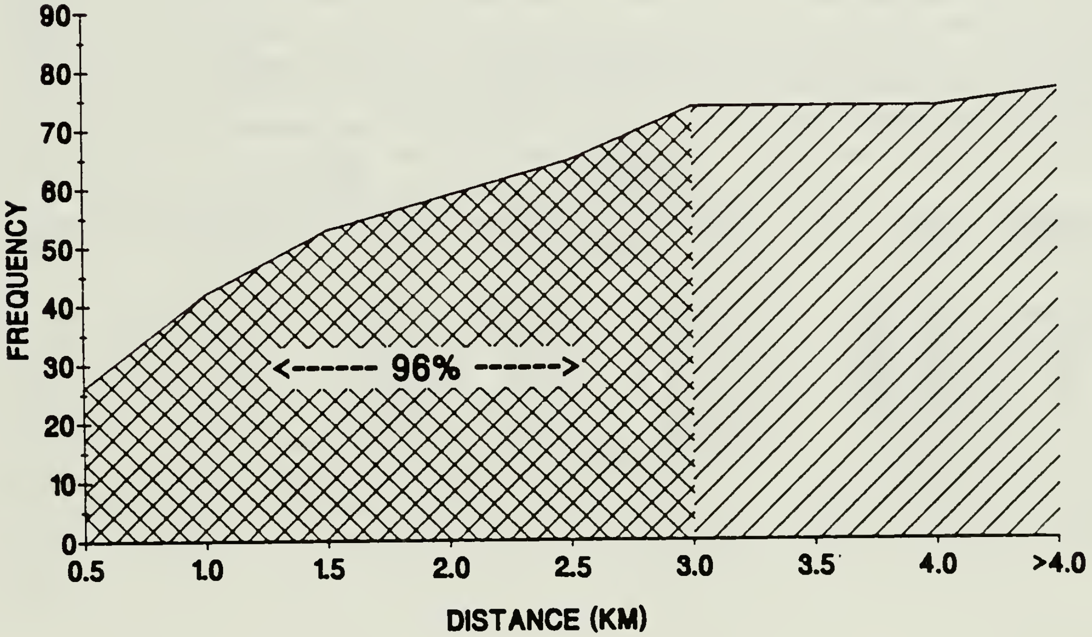


Fig. 7. Frequency (upper graph) and cumulative frequency (lower graph) distributions for distance between consecutive-day locations of radiomonitored otters in winters of 1985-86 and 1986-87.

## Distribution

Otters are distributed throughout VNP and can be observed in association with all water types. Visual observations of unmarked family groups and estimated summer home ranges of radioed family groups indicate that shallow, backwater bays of the large lakes are important for raising young.

During four track surveys conducted in the winter of 1985-86, 258.5 km of shoreline on Namakan Reservoir and 104.75 km of shoreline on Rainy Lake were searched for otter sign. Total otter sign encountered ranged from .21 sign/km on Namakan Reservoir to .41 sign/km on Rainy Lake (Table 12). These surveys resulted in 95 straight-line distances between otter sign (Table 13). There was no detectable difference in the average distance between adjacent otter sign on the two lakes ($P > 0.05$).

Table 12. Results of track surveys, winter 1985-86.

| | | NAMAKAN | | RAINY | |
|---|---|---|---|---|---|
| SURVEY | DATE | KM | SIGN/KM | KM | SIGN/KM |
| 1 | 1/3/86 | 147.00 | 0.27 | ----- | ---- |
| 2 | 1/31/86 | 82.75 | 0.33 | 64.00 | 0.41 |
| 3 | 3/24/86 | 14.50 | 0.28 | ----- | ---- |
| 4 | 3/26/86 | 14.25 | 0.21 | 40.75 | 0.32 |
| | TOTALS | 258.50 | $\bar{X}=0.27$ | 104.75 | $\bar{X}=0.37$ |

Table 13. Straight-line distance between adjacent otter sign observed during 3 surveys conducted the winter of 1985-86.

| | NAMAKAN | | | RAINY | | |
|---|---|---|---|---|---|---|
| SURVEY | N | MEAN | SE | N | MEAN | SE |
| 1 | 38 | 1.08 | 0.177 | -- | ---- | ----- |
| 2 | 22 | 0.56 | 0.260 | 23 | 1.15 | 0.221 |
| 4 | -- | ---- | ----- | 12 | 1.33 | 0.265 |
| MEAN = | 30<br>(N=60) | 0.82 | | 17.5<br>(N=35) | 1.24 | |

* Survey #3 sample too small to be included in analysis.

Sign surveys were intensified the winter of 1986-87 by making repeated searches of shorelines on both RLSA and NRSA. The entire shoreline could not be covered during each survey, although in most cases coverage was greater than 80% (Table 14). There was no detectable difference in either total or fresh sign/km between the two intensive study areas (P > 0.10). Surveys conducted the winter of 1986-87 resulted in 192 straight-line distances between adjacent fresh sign (Table 15). We found no significant difference in straight-line distances between adjacent fresh sign when tested both between lakes and among surveys (P > 0.05).

During both winters there were slightly more sign/km on Rainy Lake than on Namakan Reservoir and yet data suggests there are fewer otters/km of shore on RLSA (see Abundance section). This discrepancy may be due to an abundance of under-ice air cavities on Namakan Reservoir, which are formed when dropping water levels cause ice to "hang up" on incongruities in the shoreline (Fig. 8). These cavities are ideal resting sites and may provide under-ice latrines and travel routes that are less available to otters on Rainy Lake.

The straight-line distance between adjacent sign observed during surveys the two winters varied considerably, but these distances are probably not good indicators of otter density since they are largely dependent on whether bays and peninsulas exist between sign locations.

Table 14. Results of 1986-87 winter track surveys in VNP, Minnesota.

| STUDY AREA | SURVEY | # OBS'S | KM SHORE COVERED | PERCENT COVERAGE | TOTAL SIGN PER KM | FRESH SIGN PER KM |
|---|---|---|---|---|---|---|
| NRSA | 1 | 5 | 78.50 | 96 | 0.52 | 0.19 |
| | 2 | 2 | 81.78 | 100 | 0.35 | 0.28 |
| | 3 | 2 | 66.15 | 81 | 0.62 | 0.14 |
| | 4 | 2 | 81.78 | 100 | 0.33 | 0.24 |
| | 5 | 2 | 64.98 | 79 | 0.15 | 0.07 |
| | 6 | 3 | 66.38 | 81 | 0.33 | 0.09 |
| | 7 | 2 | 78.69 | 96 | 0.37 | 0.27 |
| SUBTOTALS: | 7 | | 518.26 | | | |
| MEAN= | | | 74.04 | 90 | 0.38 | 0.18 |
| S.D.= | | | 7.79 | 10 | 0.15 | 0.09 |
| RLSA | 1 | 0 | ----- | --- | ---- | ---- |
| | 2 | 3 | 84.20 | 95 | 0.50 | 0.11 |
| | 3 | 3 | 79.83 | 90 | 0.71 | 0.20 |
| | 4 | 3 | 88.86 | 100 | 0.29 | 0.12 |
| | 5 | 3 | 86.32 | 97 | 0.49 | 0.19 |
| | 6 | 3 | 88.86 | 100 | 0.51 | 0.28 |
| | 7 | 3 | 62.82 | 71 | 0.46 | 0.25 |
| SUBTOTALS: | 6 | | 490.89 | | | |
| MEAN= | | | 81.82 | 92 | 0.49 | 0.19 |
| S.D.= | | | 9.90 | 11 | 0.13 | 0.07 |

Table 15. Straight-line distance between fresh otter sign for each survey conducted the winter of 1986-87 in VNP, Minnesota.

|  | NRSA |  |  | RLSA |  |  |
|---|---|---|---|---|---|---|
| SURVEY | N | MEAN | SE | N | MEAN | SE |
| 1 | 15 | 1.09 | 0.230 | - | ---- | ----- |
| 2 | 23 | 0.56 | 0.116 | 9 | 0.86 | 0.194 |
| 3 | 9 | 1.31 | 0.394 | 16 | 0.76 | 0.240 |
| 4 | 20 | 0.63 | 0.087 | 11 | 1.05 | 0.203 |
| 5 | 5 | 1.70 | 0.367 | 16 | 0.62 | 0.156 |
| 6 | 6 | 1.62 | 0.946 | 25 | 0.44 | 0.052 |
| 7 | 21 | 0.77 | 0.225 | 16 | 0.67 | 0.128 |
| TOTALS= | 99 |  |  | 93 |  |  |
| MEAN= | 14 | 1.10 |  | 16 | 0.73 |  |

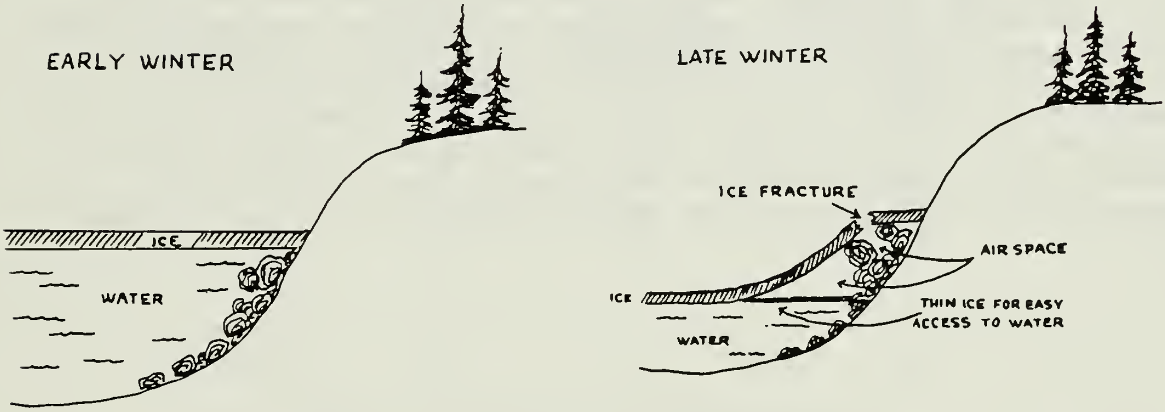


Fig. 8. Ice cavities formed by dropping water levels in winter. Namakan Reservoir, with a winter drawdown seven times greater than Rainy Lake, has an abundance of ice fractures and air cavities along its shoreline.

## Present Abundance

Method 1: From direct observations of marked and unmarked otters during the 1986 summer field season we, estimated the population at 19 otters on RLSA and 28 otters on NRSA. These otters used a combined total of 170.6 km of shoreline on the main lakes within the intensive study areas (including islands), for an estimated 1 otter per 3.6 km of shoreline. With a total shoreline length of 970.3 km on the large lakes within VNP boundaries, it is projected that a population of approximately 270 otters inhabited the main lakes of VNP during the summer of 1986. This estimate is conservative and based on 24 live-captures, 55 observations of radioed otter groups involving 116 otter sitings, and 27 different observations of unmarked otter groups involving 35 otter sitings.

Method 2: During the two winters of snow-tracking, we were able to discern the number of otters traveling in a group above ice on 50 occasions. Additionally, we tallied the known associations of radioed otters over the two winters to get an estimate of average group size (Table 16). The most conservative estimate of 1.7 otters per group for calculations was used for final calculations.

The probability of detecting radiomonitored otters by finding fresh tracks in their home range was calculated for each survey to account for differences due to weather, time of year and missed or incorrectly interpreted tracks (Table 17). Although we had a total of nine groups radioed during the winter of 1986-87, only seven used shorelines within the study areas (four on NRSA and three on RLSA). All seven groups were known to have been on the shoreline of the study areas during only three of the surveys (survey #1 was completed for NRSA only). At no time were all seven groups detected by fresh tracks within their home ranges. The probabilities of detection ranged from 0.50 to 0.83 (Table 17).

Table 16. Calculation of average group size during winter 1985-86 and 1986-87.

| | FREQUENCY | | |
|---|---|---|---|
| GROUP SIZE | TRACKS WINTER 85-86 | TRACKS WINTER 86-87 | KNOWN WINTERS 86,87 |
| 1 | 12 | 13 | 11 |
| 2 | 7 | 8 | 5 |
| 3 | 3 | 5 | 3 |
| 4 | 1 | 1 | 1 |
| OTTERS = | 39 | 48 | 34 |
| GROUPS = | 23 | 27 | 20 |
| MEAN = | 1.70 | 1.78 | 1.70 |
| S.D. = | 0.88 | 0.89 | 0.92 |

Table 17. Probability of radiomonitored otter being detected by tracks in their home range.

| SURVEY | GROUPS KNOWN | GROUPS DETECTED | | PROBABILITY b OF DETECTION |
|---|---|---|---|---|
| 1 /a | 2 | 1 | | 0.50 |
| 2 | 7 | 4 | | 0.57 |
| 3 | 6 | 5 | | 0.83 |
| 4 | 6 | 3 | | 0.50 |
| 5 | 4 | 3 | | 0.75 |
| 6 | 7 | 5 | | 0.71 |
| 7 | 7 | 5 | | 0.71 |
| TOTAL | 39 | 26 | MEAN | 0.66 |

a = Survey completed for NRSA only.
b = P = groups detected/groups known.

Using the equation N=(R+(A/P))/km, we calculated the mean number of otter/km of lakeshore as 0.152 for NRSA and 0.126 for RLSA (Table 18). Multiplying the 95% confidence intervals for the mean otter/km (Table 19) by length of shoreline produced estimates of between 9 and 16 otters on NRSA and between 7 and 13 otters on RLSA during the winter of 1986-87 (Table 20). Using these estimates we found no significant difference in the number of otter/km of shoreline between the two intensive study areas (t = 0.60, 11 df, P > 0.50).

Table 18. Results of calculations for the number of otter per km of shoreline during surveys conducted the winter of 1986-87 in VNP, Minnesota.

| | | NAMAKAN | | | | RAINY | | | |
|---|---|---|---|---|---|---|---|---|---|
| SURVEY | P | # KNOWN | # ADD'L | KM SHORE | OTTERS / KM | # KNOWN | # ADD'L | KM SHORE | OTTERS / KM |
| 1 | 0.50 | 2 | 3.4 | 78.50 | 0.11 | - | --- | ----- | ---- |
| 2 | 0.57 | 7 | 6.8 | 81.78 | 0.23 | 4 | 3.4 | 84.20 | 0.12 |
| 3 | 0.83 | 2 | 3.4 | 66.15 | 0.09 | 4 | 1.7 | 79.83 | 0.08 |
| 4 | 0.50 | 6 | 5.1 | 81.78 | 0.20 | 5 | 3.4 | 88.86 | 0.13 |
| 5 | 0.75 | 1 | 5.1 | 64.98 | 0.12 | 4 | 3.4 | 86.32 | 0.10 |
| 6 | 0.71 | 5 | 3.4 | 66.38 | 0.15 | 5 | 5.1 | 88.86 | 0.14 |
| 7 | 0.71 | 6 | 5.1 | 78.69 | 0.17 | 5 | 5.1 | 62.82 | 0.19 |
| MEAN= | 0.65 | 4.1 | 4.6 | 74.04 | 0.15 | 4.5 | 3.7 | 81.82 | 0.13 |
| S.D.= | 0.12 | 2.2 | 1.2 | 7.21 | 0.05 | 0.5 | 1.2 | 9.04 | 0.04 |

Table 19. 95% confidence limits for the estimated number of otters per km of shore on two study areas in VNP, Minnesota.

| STUDY AREA | NUMBER OF SURVEYS | MEAN OTTER / km | SE | 95% C.I. LOWER LIMIT | 95% C.I. MEAN | 95% C.I. UPPER LIMIT |
|---|---|---|---|---|---|---|
| NRSA | 7 | 0.152 | 0.017 | 0.110 | 0.152 | 0.195 |
| RLSA | 6 | 0.126 | 0.015 | 0.088 | 0.126 | 0.164 |

Table 20. 95% confidence limits for the estimated number of otters using the shore of the two study areas.

| STUDY AREA | SHORE LENGTH (km) | 95% C.I. LOWER LIMIT | 95% C.I. MEAN | 95% C.I. UPPER LIMIT |
|---|---|---|---|---|
| NRSA | 81.78 | 9 | 12 | 16 |
| RLSA | 88.86 | 7 | 10 | 13 |

Method 2 resulted in a much smaller estimate of abundance on the two study areas than did Method 1. We attribute this difference to three factors:

1) Restricted range - Otters that used the large lakes as part of their home range during summer may move to inland waters for the majority of winter. This was true for 1 of 6 radiomonitored otters (16.7%) during the winter of 1985-86 and 2 of 11 radiomonitored otters (18.2%) during the winter of 1986-87. Two other radiomonitored otters were located on the large lakes only briefly in the winter of 1986-87. Thus, the proportion of otters spending the majority of winter associated with inland waters may range from 16-35%. These otters would be observed and counted in Method 1 but would go undetected in Method 2. The number of otters using inland areas in winter was not determined, but surveys up beaver flowages resulted in some of the highest estimates of sign/km (.71 sign/km in 85-86). However, the frequency of otter sign is probably dependent on the spacing of beaver dams. Thin ice around dams provides easy access and a single otter could easily travel the length of a creek.

2) Natural mortality - It can be expected that some natural mortality of the less fit animals occurs at the onset of winter. Thus some of the differences may be actual reductions in otter numbers.

3) Conservative estimate - Method 2 was designed as a relatively unbiased estimator to reflect relative abundance for comparing study areas. Before a reasonable estimate of population size can be made with this method, the extent of home range overlap between individuals would have to be known.

Thus, Method 1 probably more closely reflects the true abundance of otters in VNP, while Method 2 provides, to the extent possible, a reasonably unbiased estimator to compare study areas.

## Food Habits

The literature shows fish as the prey most frequently fed on by otter (Lagler and Ostenson 1942; Ryder 1955; Hamilton 1961; Sheldon and Toll 1964; Knudsen and Hale 1968; Toweill 1974; Lauhacinda and Hill 1977; Cooley 1983; Melquist and Hornocker 1983). Otters feed primarily on fish such as the Centrarchids and Cyprinids which occupy relatively shallow areas (Lagler and Ostenson 1942; Hamilton 1961; Sheldon and

Toll 1964). Ryder (1955) argued that utilization of fish was in proportion to their abundance but in inverse proportion to their swimming ability. Recent studies support this contention (Hamilton 1961; Sheldon and Toll 1964; Erlinge 1968; Knudsen and Hale 1968; Melquist and Hornocker 1983).

The importance of crayfish in the otter's diet is also well documented, but they usually rank second behind fish in frequency of occurrence (Hamilton 1961; Sheldon and Toll 1964; Knudsen and Hale 1968). However, Liers (1951) argued that, when crayfish are available, otters prefer to feed on them. Grenfell (1974) found crayfish to be the most important food for otter during all seasons in a central California marshland, and Tumilson and Karnes (1987) showed crayfish to be more important than fish during winter and spring in man-regulated swamp habitat in Arkansas. Tumilson and Karnes (1987) speculated that low water levels in summer caused crayfish to seek refuge in burrows while fish became more concentrated. Thus, fish were preyed on more frequently in summer and fall only because the easier-to-catch crayfish became more difficult to obtain.

A similar effect of water levels on the availability of fish and crayfish was observed in Florida (Cooley 1983). In that study, the proportions of crayfish in otter diets increased as a direct result of increases in crayfish populations due to fluctuating water levels. Seasonally fluctuating water levels are more productive for crayfish than constant water levels (Kushlan and Kushlan 1979, cited in Cooley 1983).

In VNP, fish occurred in 72% and crayfish in 71% of the 796 otter scats analyzed from summer and winter. Other prey included: aquatic insects (14%); amphibians (11%); molluscs (2%); and birds and mammals ( < 1%) of all scats (Fig. 9) (Tables 21 - 23).

Scat collection sites on inland waters varied depending on location, but fish and crayfish were the primary prey taken (Table 21). On the large lakes, predation on fish and crayfish depended on season and water regime (Rainy Lake and Namakan Reservoir). In winter, fish occurred more frequently than crayfish in the diet of otters on both Rainy Lake and Namakan Reservoir (Fig. 10). In fact, the diets were nearly identical on the two water regimes in winter (Table 22). In summer, high utilization of fish continued on Rainy Lake, but on Namakan Reservoir the diet of otters shifted dramatically towards crayfish (Fig. 10).

At least two species of crayfish have been identified in large numbers in VNP: Orconectes virilis and O. immunis (J. Helgen, Bio. Dept., St. Olaf Coll., pers. comm.). O. virilis occupies gravelly and rocky substrate. Although both males and females of this species occur in shallow water during summer, in winter the females migrate to deeper water where 4-5 months of low temperatures and darkness are required for ovarian growth (Payne 1978). O. immunis occupies shallow bays and sloughs year-around where it burrows into mud bottoms to over-winter (Payne 1978). While we did not identify the species of crayfish in otter scats it is likely that species composition, movements, and relative abundance of crayfish on the two water regimes differ dramatically and account for the observed differences in otter feeding habits.

Otters are opportunistic foragers (Melquist et al. 1981; Tumlison and Karnes 1987) and their food habits are determined by "realized" prey availability rather than observed availability (Ryder 1955; Knudsen and Hale 1968; Cooley 1983). This availability may be determined by such factors as: 1) detectability and mobility of prey; 2) habitat availability for various prey species; 3) environmental factors such as water depth and temperature; and 4) seasonal changes in prey abundance and distribution in relation to otter foraging habitat.

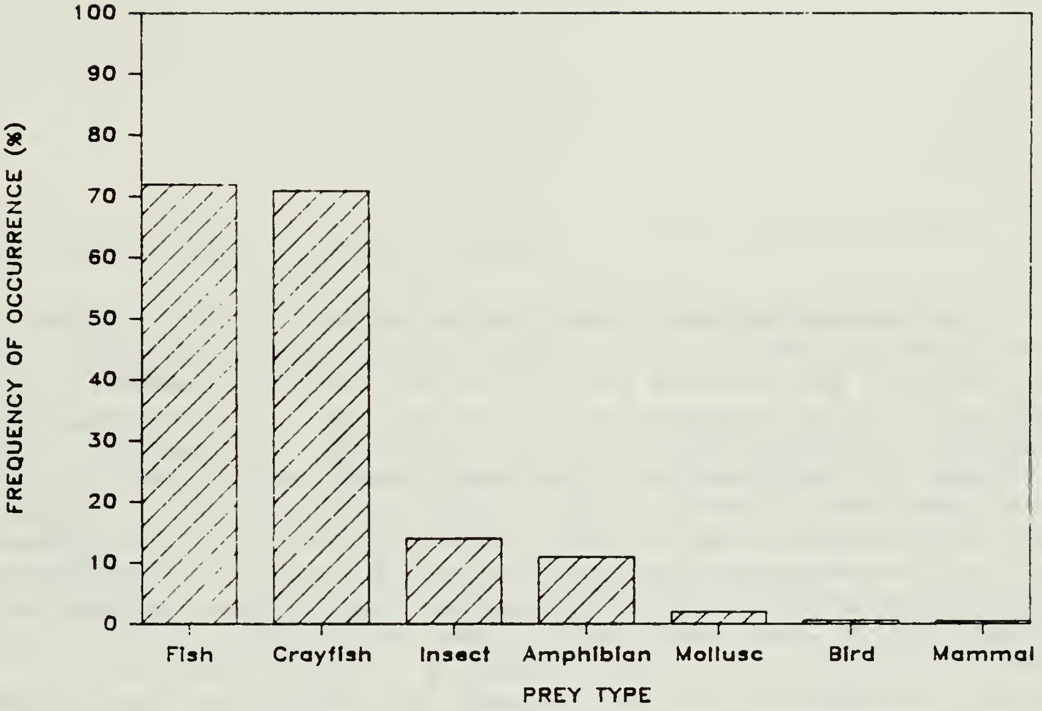


Fig. 9. Frequency of occurrence of various prey items in 796 otter scats collected during summer and winter in VNP, Minnesota.

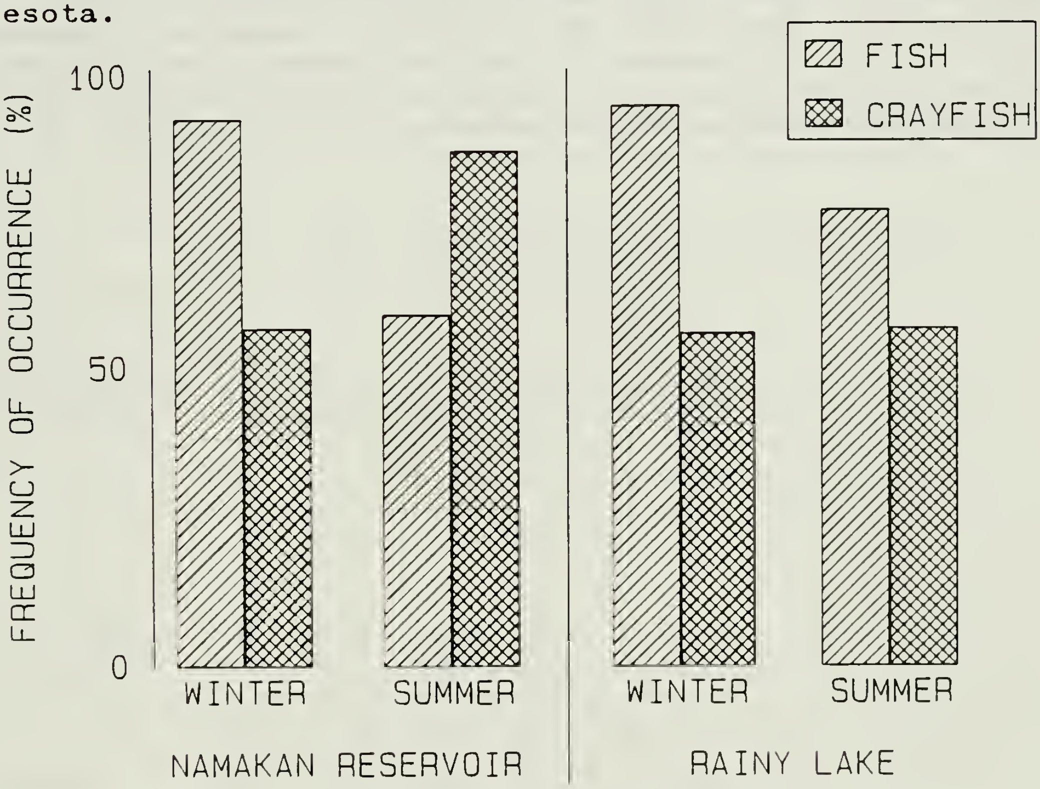


Fig. 10. Frequency of occurrence of crayfish and fish in otter scats collected during winter and summer on Namakan Reservoir and Rainy Lake, VNP, Minnesota.

It is suggested here that the observed difference in otter food habits is due, in part, to a rapid increase in the crayfish population during summer on the Namakan Reservoir. This increase could be caused by an abundance of detritus and associated microbiota which are a major component in the diet of crayfish (Momot et al. 1978). Kepner and Stottlemyer (1988) argued that water fluctuations could be contributing to the productivity (i.e., detritus load) of the Namakan Reservoir lakes by causing a die-off of aquatic vegetation in the draw-down zone, thus increasing decomposition when lake levels are restored in spring. Kraft (1988) concluded that large numbers of some species of benthic organisims die as a result of the water draw-downs, further increasing the available food resources for crayfish in spring.

Crayfish can be important in determining the relative importance of detrition and primary production in the littoral food web (Momot et al. 1978). Lorman and Magnuson (1978) urge that changes in species composition, abundance, and population structure of crayfish should be considered in the management of aquatic systems.

Table 21. Frequency of occurrence of prey items in otter scats collected in inland waters.

| SITE | (N) | FISH | CRAY | AVES | MAMM | INSC | AMPH | MOLL |
|---|---|---|---|---|---|---|---|---|
| INLAND WATERS | | | | | | | | |
| SUMMER: | | | | | | | | |
| CHAIN OF LAKES | 34 | 73.5 | 52.9 | 0.0 | 0.0 | 26.5 | 8.8 | 0.0 |
| EK LAKE | 8 | 87.5 | 75.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| O'LEARY LAKE | 4 | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PONDS/CREEKS | 10 | 80.0 | 100.0 | 0.0 | 0.0 | 20.0 | 10.0 | 0.0 |
| Sub totals | 56 | 71.4 | 67.9 | 0.0 | 0.0 | 19.6 | 7.1 | 0.0 |
| WINTER: | | | | | | | | |
| PONDS/CREEKS | 27 | 100.0 | 22.2 | 0.0 | 0.0 | 33.3 | 37.0 | 0.0 |
| TOTALS | 83 | 80.7 | 53.0 | 0.0 | 0.0 | 24.1 | 16.9 | 0.0 |

Table 22. Frequency of occurrence of prey items in otter scats collected during winter on the two study areas.

| SITE | (N) | FISH | CRAY | AVES | MAMM | INSC | AMPH | MOLL |
|---|---|---|---|---|---|---|---|---|
| NRSA | | | | | | | | |
| WINTER SURVEYS | 53 | 92.5 | 41.5 | 0.0 | 0.0 | 34.0 | 15.1 | 0.0 |
| SUPPLEMENTALS | 51 | 90.2 | 74.5 | 0.0 | 0.0 | 27.5 | 15.7 | 2.0 |
| Sub totals | 104 | 91.3 | 57.7 | 0.0 | 0.0 | 30.8 | 15.4 | 1.0 |
| RLSA | | | | | | | | |
| WINTER SURVEYS | 18 | 94.4 | 38.9 | 0.0 | 0.0 | 33.3 | 5.6 | 0.0 |
| SUPPLEMENTALS | 26 | 92.3 | 65.4 | 0.0 | 0.0 | 42.3 | 23.1 | 0.0 |
| Sub totals | 44 | 93.2 | 54.5 | 0.0 | 0.0 | 38.6 | 15.9 | 0.0 |
| TOTALS | 148 | 91.9 | 56.8 | 0.0 | 0.0 | 33.1 | 15.5 | 0.7 |

Tables 23. Frequency of occurrence of prey items in otter scats collected during summer on large lakes in VNP.

| SITE | (N) | FISH | CRAY | AVES | MAMM | INSC | AMPH | MOLL |
|---|---|---|---|---|---|---|---|---|
| KABETOGAMA | | | | | | | | |
| DALEY BAY | 70 | 55.7 | 95.7 | 0.0 | 1.4 | 18.6 | 2.9 | 1.4 |
| LOST BAY | 21 | 57.1 | 81.0 | 0.0 | 0.0 | 0.0 | 4.8 | 0.0 |
| SULLIVAN BAY | 24 | 83.3 | 83.3 | 4.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| LONG SLU | 11 | 72.7 | 63.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CUTOVER | 27 | 40.7 | 96.3 | 0.0 | 0.0 | 3.7 | 7.4 | 0.0 |
| SUGARBUSH | 6 | 50.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Sub totals | 159 | 58.5 | 89.9 | 0.6 | 0.6 | 8.8 | 3.1 | 0.6 |
| NAMAKAN | | | | | | | | |
| JUNCTION BAY | 24 | 70.8 | 87.5 | 0.0 | 0.0 | 12.5 | 8.3 | 8.3 |
| HOIST BAY | 31 | 32.3 | 90.3 | 0.0 | 3.2 | 25.8 | 9.7 | 0.0 |
| SOUTH GULL | 19 | 63.2 | 63.2 | 0.0 | 0.0 | 10.5 | 10.5 | 0.0 |
| KOHLER BAY | 30 | 100.0 | 86.7 | 0.0 | 0.0 | 0.0 | 3.3 | 0.0 |
| Sub totals | 104 | 66.3 | 83.7 | 0.0 | 1.0 | 12.5 | 7.7 | 1.9 |
| SAND POINT | | | | | | | | |
| GRASSY BAY | 79 | 63.3 | 86.1 | 0.0 | 0.0 | 7.6 | 29.1 | 0.0 |
| BROWNS BAY | 30 | 33.3 | 80.0 | 3.3 | 0.0 | 13.3 | 23.3 | 6.7 |
| CENTRAL | 9 | 55.6 | 88.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| LITTLE ISLAND | 2 | 100.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Sub totals | 120 | 55.8 | 85.0 | 0.8 | 0.0 | 8.3 | 25.0 | 1.7 |
| TOTALS | 383 | 59.8 | 86.7 | 0.5 | 0.5 | 9.7 | 11.2 | 1.3 |
| RAINY | | | | | | | | |
| CRANBERRY BAY | 30 | 76.7 | 100.0 | 3.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| ALDER CREEK | 29 | 55.2 | 86.2 | 0.0 | 0.0 | 3.4 | 0.0 | 3.4 |
| HITCHCOCK BAY | 48 | 85.4 | 58.3 | 0.0 | 4.2 | 4.2 | 14.6 | 0.0 |
| KEMPTON CHANNEL | 25 | 52.0 | 32.0 | 0.0 | 4.0 | 8.0 | 4.0 | 20.0 |
| ISTHMUS | 10 | 90.0 | 10.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NORTH EAST | 40 | 97.5 | 35.0 | 5.0 | 0.0 | 2.5 | 2.5 | 10.0 |
| TOTALS | 182 | 77.5 | 58.2 | 1.6 | 1.6 | 3.3 | 4.9 | 5.5 |

# SUMMARY OF MAJOR FINDINGS

1. Voyageurs National Park (VNP) has a relatively high density otter population. During the summer of 1986, an estimated 270 otters utilized the shoreline of the main lakes for an average of 1 otter/3.6 km of shoreline. Mean productivity was estimated at 2.6 young per breeding female.

2. Trap success was higher in VNP compared to other North American studies, averaging 41.1 trap-nights/otter with a spring low of 11.7 trap-nights/otter. Overall, trap success was higher in spring with adult males being captured more often. Adult females, on the other hand, were more easily trapped in fall and were caught more often than their juvenile offspring. There was no significant difference in trap success between Rainy Lake and Namakan Reservoir.

3. Trapped otters were generally in good physical condition. However, two were diagnosed as having chronic cystitis (urinary infection) and one suffered from adrenal failure. Mercury levels in otter fur ranged from 7.5 ppm on Kabetogama Lake to 75 ppm on Rainy Lake. Though preliminary, these concentrations are high enough for concern. In one instance a female otter was killed by wolves; however, predation on otter is probably low.

4. Adult males had larger summer home range areas with more total shoreline available than did adult females, but these parameters did not differ significantly in winter. In summer, adult male home ranges averaged 21 $km^2$ and females 3 $km^2$, while winter home ranges were 8 $km^2$ and 6 $km^2$, respectively. Adult male home ranges overlapped considerably within and between sexes. Adult females maintained exclusive home ranges with the exception of two females whose home ranges merged and overlapped coincidentally with the winter water drawdown on Namakan Reservoir.

5. Family groups used shallow, productive, backwater bays of the large lakes in summer; however, as water levels were drawn down during winter, radiomonitored females shifted their home ranges to deeper water. This shift appeared to be greater on Namakan Reservoir, where the winter drawdown is over seven times greater than on Rainy Lake.

6. All radiomonitored otters moved freely between the large lakes and adjacent interior waters in summer, but the proportion of otters spending the winter exclusively in interior waters ranged from 16-35%. The data did not reflect a difference in this tendancy between study areas or sexes.

7. Abundance of above-ice sign and straight-line distance between adjacent sign were not significantly different between study areas in either the winter of 1985-86 or 1986-87. However, Rainy Lake averaged slightly more sign/km than Namakan Reservoir in both winters. This discrepancy may be due to an abundance of under-ice cavities on Namakan Reservoir caused by ice being hung-up on shoreline incongruities when water is drawn down.

8. Relative abundance estimates based on above-ice sign and known movements of radioed otter showed no significant difference between the two intensive study areas.

9. In 796 scats analyzed, fish occurred in 72% and crayfish in 71%. Other prey included: aquatic insects (14%); amphibians (11%); molluscs (2%); and birds and mammals (<1%). Otter predation on fish and crayfish varied with season and water body. Fish was the major prey type in winter for both Rainy Lake and the Namakan Reservoir otters. Fish continued to be the major prey item in summer on Rainy Lake, but otters on Namakan Reservoir switched to a higher proportion of crayfish in their diet.

10. It is postulated that regulated lake levels influence the distribution and abundance of crayfish (a primary source of food to otters in summer) by exposing 17 to 25% of the bottom areas of Namakan Reservoir lakes. Exposure of lake bottom causes die-offs of macrophytes and benthic organisms, thus an abundant supply of detritus is available for an expanding crayfish population. The opposite would be true for Rainy Lake, where less-than-natural draw downs would dampen crayfish population fluctuations.

# MANAGEMENT RECOMMENDATIONS

1. It is recommended that fluctuations on Namakan Reservoir be reduced to more natural conditions. This would decrease the crowding and shifting of otter winter home ranges on the Namakan Reservoir.

2. Fluctuations on Rainy Lake should be increased to more natural conditions. Natural fluctuations could increase the detritus load in Rainy Lake which would increase the abundance of crayfish, a source of prey to otters.

3. The otter population should be monitored every two to three years by conducting sign surveys as in this study. These surveys would enable VNP to keep track of trends in otter abundance with or without changes in the way the lakes are fluctuated.

4. Data presented here suggests mercury could be a problem in the VNP otter population. The otter is a resident predator that is high on the aquatic food chain and therefore a good biological indicator of the health of the aquatic environment. Additional otters should be live-trapped and hair samples taken for analysis of mercury contamination. Samples should be obtained from all four large lakes in VNP. Furthermore, a comprehensive study of the existence of mercury in air, water, soils and other aquatic life should be conducted.

5. Crayfish population dynamics in relation to water drawdowns should be studied. Crayfish are important in determining primary production in the littoral food web, of which the otter is a top predator.

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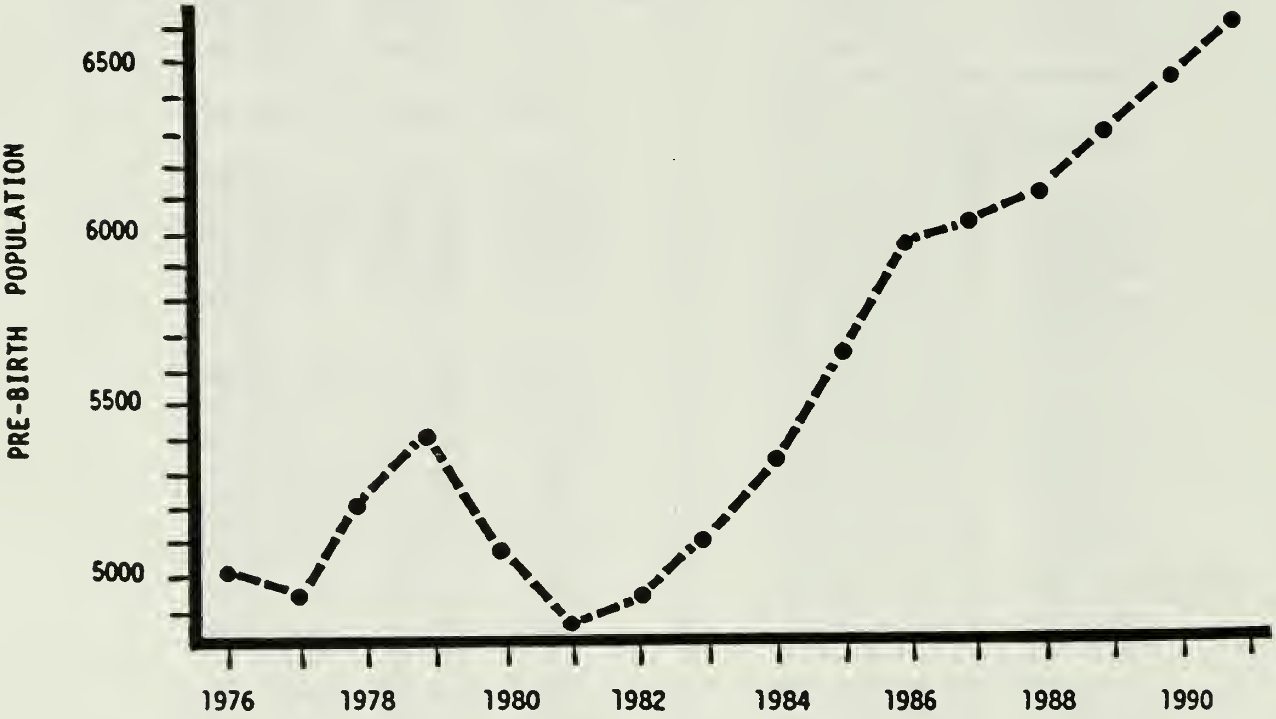
Appendix 1. Numbers of otter pelts collected at La Pointe, Madeline Island, Wisconsin from 1835 to 1848. The year 1835 would represent pelts collected the winter of 1834-35. (From Schorger 1970).

| YEAR | NUMBER OF PELTS |
|---|---|
| 1835 | 4,831 |
| 1836 | 1,842 |
| 1837 | 2,997 |
| 1838 | 1,270 |
| 1839 | 2,384 |
| 1840 | 1,574 |
| 1841 | 1,791 |
| 1842 | 1,072 |
| 1843 | 1,005 |
| 1844 | 512 |
| 1845 | 478 |
| 1846 | 1,140 |
| 1847 | 559 |
| 1848 | 321 |

Appendix 2. Minnesota Department of Natural Resources trapping statistics on river otter, 1867 to 1986.

| SEASON YEAR | SEASON LENGTH | BAG LIMIT | HARVEST | PELT VALUE | |
|---|---|---|---|---|---|
| | | | | EACH | TOTAL |
| 1867-68 | 11/15-04/30 | NONE | UNK | UNK | UNK |
| 1869-74 | UNPROTECTED | NONE | UNK | UNK | UNK |
| 1875-1916 | 11/01-04/30 | NONE | UNK | UNK | UNK |
| 1917-44 | CLOSED | 0 | 0 | 0.00 | 0.00 |
| 1944-45 | 12/01-12/15 | 1 | 46 | 30.00 | 1380.00 |
| 1945-51 | CLOSED | 0 | 0 | 0.00 | 0.00 |
| 1951-52 | 04/10-04/24 | 1 | 81 | UNK | 0.00 |
| 1952-53 | 12/01-12/15 | 3 | 0 | 0.00 | 0.00 |
| 1953-54 | CLOSED | 0 | 0 | 0.00 | 0.00 |
| 1954-55 | 04/15-04/30 | 3 | 391 | 20.00 | 7820.00 |
| 1955-56 | 03/31-04/14 | | | | |
| b | 04/14-04/28 | 3 | 246 | 20.00 | 4920.00 |
| 1956-57 | 04/13-04/27 | | | | |
| b | 03/30-04/13 | 3 | 264 | 20.00 | 5280.00 |
| 1957-58 | 04/14-04/28 | 3 | 549 | 20.00 | 10980.00 |
| 1958-59 | 04/12-04-26 | 3 | 450 | 21.58 | 9711.00 |
| 1959-60 | 04/16-04/30 | 3 | 428 | 18.30 | 7832.40 |
| 1960-61 | 04/15-04/29 | 3 | 485 | 20.00 | 9700.00 |
| 1961-62 | 04/14-04/28 | | | | |
| b | 04/07-04/21 | 3 | 273 | 22.00 | 6006.00 |
| 1962-63 | 04/13-04/27 | 3 | 425 | 22.00 | 9350.00 |
| 1963-64 | 05/05-04/19 | 3 | 237 | 32.50 | 7702.50 |
| 1964-65 | 04/12-04/26 | 3 | 391 | 30.00 | 11730.00 |
| 1965-66 | 04/16-04/30 | 3 | 480 | 25.00 | 12000.00 |
| 1966-67 | 04/16-04/30 | 3 | 529 | 16.00 | 8464.00 |
| 1967-68 | 04/15-04/29 | 3 | 447 | 17.00 | 7599.00 |
| 1968-69 | 04/14-04/28 | 3 | 356 | 25.00 | 8900.00 |
| 1969-70 | 04/13-04/27 | 3 | 488 | 25.00 | 12200.00 |
| 1970-71 | 03/07-03/21 | 3 | 121 | 25.00 | 3025.00 |
| 1971-72 | 04/16-04/30 | 3 | 784 | 25.00 | 19600.00 |
| 1972-73 | 04/16-04/30 | 3 | 1079 | 32.50 | 35067.50 |
| 1973-74 | 03/17-03/31 | 3 | 185 | 45.00 | 8325.00 |
| 1974-75 | 04/16-04/30 | 3 | 322 | 32.50 | 10465.00 |
| 1975-76 | 04/16-04/30 | 3 | 0 | 37.00 | 0.00 |
| 1976-77 | CLOSED | 0 | 0 | 0.00 | 0.00 |
| 1977-78 | 02/01-02/15 | 3 | 492 | 41.25 | 20295.00 |
| 1978-79 | 12/01-12/15 | 3 | 636 | 58.85 | 37428.60 |
| 1979-80 | 11/15-11/29 | 3 | 1186 | 63.35 | 75133.10 |
| 1980-81 | 11/15-11/29 | 2 | 1111 | 32.80 | 36440.80 |
| 1981-82 | 11/14-11/28 | 2 | 471 | 29.80 | 14035.80 |
| 1982-83 | 11/13-11/27 | 2 | 385 | 25.65 | 9875.25 |
| 1983-84 | 11/12-11/26 | 2 | 408 | 24.80 | 10118.40 |
| 1984-85 | 11/17-12/01 | 2 | 529 | 21.56 | 11405.24 |
| 1985-86 | 11/16-12/15 | 3 | 559 | 20.81 | 11632.79 |
| 1986-87 | 11/01-11/30 | 3 | 777 | 24.15 | 18764.55 |

Appendix 3. Minnesota Department of Natural Resources otter population model, 1976-1991. Non-harvest mortality for juveniles was estimated at 25% summer, 15% winter; for yearlings 10% summer, 10% winter; and for adults 6% summer, 6% winter. Harvest mortality was increased 20% over regestered harvest to compensate for incidental and illegal take (MDNR unpubl. data).



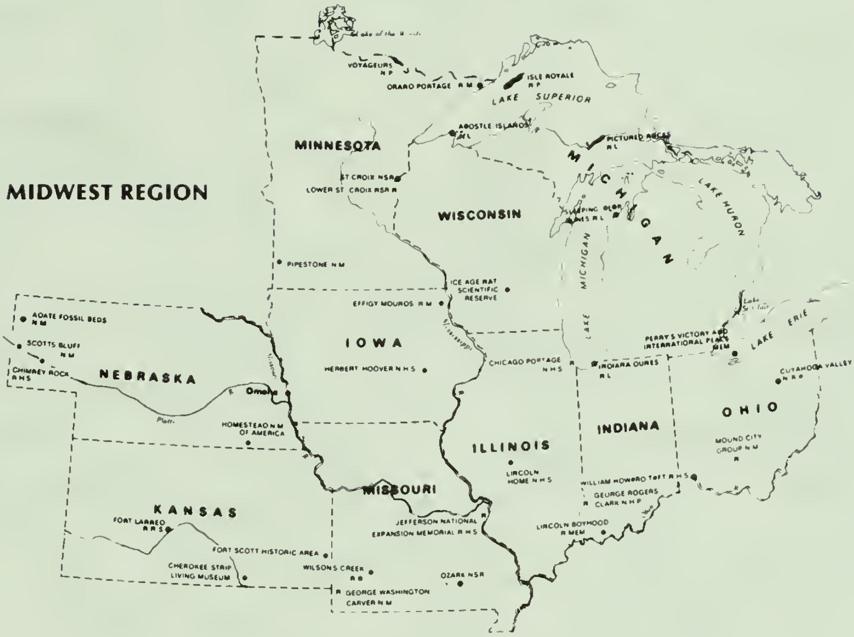
Appendix 4. Area, depth, length and volume of the 4 large lakes in Voyageurs National Park. (From Kepner and Stottlemeyer 1988).

| | KABETOGAMA | NAMAKAN | RAINY | SAND PT |
|---|---|---|---|---|
| LAKE AREA (ha*$10^3$) | 9.8 | 10.0 | 8.9 | 3.4 |
| ISLAND AREA (ha) | 862.0 | 1191.0 | ---- | 156.0 |
| MAX DEPTH (m) | 15.2 | 36.6 | 49.1 | 56.1 |
| MEAN DEPTH (m) | 9.1 | 14.9 | 9.9 | 13.1 |
| LENGTH (km) | 24.1 | 25.7 | 74.0 | 14.5 |
| VOLUME ($10^6$ $m^3$) | 895.0 | 1503.00 | 8530.0 | 446.0 |

Appendix 5. Weight, zygomatic breadth, and tooth wear of otters aged by cementum analysis. Otter carcasses collected from trappers adjacent to Voyageurs National Park, Minnesota during the winter of 1985-86. Age analysis by Minnesota Department of Natural Resources.

| CARCASS NUMBER | WEIGHT (kg) | ZYGOMATIC BREADTH (cm) | TOOTH WEAR | SEX | AGE (YEARS) |
|---|---|---|---|---|---|
| 1 | UNK | 7.0 | LITE | MALE | <1 |
| 2 | UNK | 7.6 | LITE | MALE | <1 |
| 3 | UNK | 7.0 | MED | FEMALE | 2.5 |
| 4 | 7.0 | 8.0 | HVY | MALE | 4.5 |
| 5 | 8.75 | 7.8 | MED | MALE | 3.5 |
| 6 | 8.25 | 8.0 | MED | MALE | 4.5 |
| 14 | 5.75 | 7.3 | LITE | MALE | <1 |
| 15 | 8.0 | 7.3 | MED | MALE | 1.5 |
| 16 | 4.75 | 7.0 | HVY | FEMALE | 1.5 |
| 17 | 7.5 | 7.5 | HVY | MALE | --- |
| 19 | 8.75 | 7.8 | LITE | MALE | 3.5 |
| 20 | 9.75 | 7.7 | LITE | MALE | 4 - 5.5 |
| 21 | 8.0 | 7.5 | MED | MALE | 1.5 |
| 22 | 9.25 | 7.7 | MED | MALE | 5.5 |
| 23 | 7.75 | 7.5 | MED | MALE | 5.5 |
| 29 | 9.0 | 7.8 | HVY | MALE | 7.5 |
| 30 | 6.0 | UNK | LITE | MALE | <1 |
| 31 | UNK | 6.7 | LITE | UNK | --- |
| 32 | UNK | 7.2 | LITE | FEMALE | --- |

Note: Measurements taken from skinned carcasses. Weights and zygomatic breadth are not directly comparable to measurements on live otters.



The National Park Service's Midwest Region covers 33 park units located in 10 states in the Great Plains and Great Lakes area (Nebraska, Kansas, Missouri, Iowa, Minnesota, Wisconsin, Michigan, Illinois, Indiana, and Ohio). The physical and biological diversity of the Region is reflected in the variety of research conducted in the parks. Current research subjects range from a survey of prairie vegetation in several small parks to the ecology of boreal forests at Voyageurs; from threatened plants in a number of parks to endangered wolves at Isle Royale; from hydrology of springs at Ozark to air pollution at Indiana Dunes; and from recreational boating use patterns on the Lower Saint Croix to hiking and campground use at Isle Royale. For more information on the National Park Service's Midwest Regional science program, please write:

Regional Chief Scientist
National Park Service
Midwest Regional Office
1709 Jackson Street
Omaha, Nebraska 68102

March 3, 1849

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